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Smelting Number

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Clipping from article in
American Machinist, Aug. 24'16.

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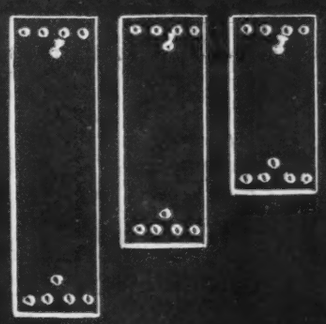

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Engineering and Mining Journal

VOLUME 102 OCTOBER 7, 1916 NUMBER 15

Metallurgical Works Tramways

By W. C. Capron* and C. R. Kuzell†

SYNOPSIS—Steam locomotives are in most general use in metallurgical plant service because of their complete utility on all tracks. Electric locomotives partly make up their deficiency in this respect by using crab or reel attachments to supply traction over tracks lacking power supply. Compressed-air locomotives, though well adapted to intermittent service, have an efficiency of only 18% in the utilization of their power. Gasoline locomotives have a low first cost, but are not well adapted to intermittent service. Cars used for all sorts of metallurgical service detailed; operating costs compared.

In writing this article descriptive of tramways our aim is to limit its scope to tramways found at metallurgical works. It has to do with the current practice in interdepartmental haulage in metallurgical works of various kinds and of different magnitudes. The field is so large and comprises so many different modifications of engines, motors and cars that space limits the thoroughness of description. Undoubtedly there are installations embracing interesting features which could have been described in this paper, but which did not happen to come under our observation.

Operating costs have been rather difficult to obtain, especially on a comparable basis, but enough have been presented to show the wide variation according to conditions and to the size of the system. An attempt has also been made to compare the operating costs of different systems at similar plants. Figures of this kind are always welcome to the engineer, but it must be remembered that such a comparison is by no means absolute, because no two systems or tramming layouts can possibly be alike or have exactly the same work to perform. The data for this paper were practically all furnished by officials of the companies whose equipment is described. Our requests for various information were very courteously and painstakingly complied with. Sincere thanks are due to those gentlemen who have so willingly allowed descriptions of their equipment and their records to be put into print and even compared with others.

Selection of equipment for tramways is governed by the conditions met with in individual cases and is usually a separate problem for each installation. One system cannot be installed in exactly the same manner at two plants and produce identical results unless conditions happen to be similar. Features of several successful systems suited to meet the needs of a proposed new system, however, can be combined into a harmoniously and economically operating unit, hence the advantage of studying that which operates successfully elsewhere.

FIG. 1. 10½-TON, 20-IN. GAGE

FIG. 2. 30-TON, 36-IN. GAGE

Figs. 1 and 2—Steam locomotives, contrasting light and heavy designs

The motive power available at the least expense per unit of power expressed in drawbar pull will usually decide the kind of locomotive and the details will be decided by the particular service to be performed. Sometimes, however, safety, utility or other causes demand the selection of motive power that does not furnish drawbar pull at the lowest possible cost. Assuming that the engine efficiency is the same, the factors of power cost that vary with plant location are cost of fuel, labor, supplies, depreciation and upkeep. One locality may have the advantage of cheap coal, another of hydroelectric power, another of cheap gasoline and oil. Western smelteries have to contend with higher costs for labor and supplies than the metallurgical works in the East. Any

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one of these advantages or disadvantages should influence the selection of the kind of locomotive and the whole traming system.

The use of steam locomotives is widespread. There are many variations met with in design, weight, track gage, etc. Fig. 1 illustrates a 10½-ton engine used in a New England plant that utilizes a very narrow track gage. Fig. 2 shows a much heavier type, common in Middle Western steel plants. This particular one is also adapted to a narrow-gage, 36-in. system. Fig. 3 shows a low, comparatively light engine used on a standard-gage system in a Nevada copper smeltery. Its two main features are its small height of only 6 ft. 6 in. above rails and its short wheelbase of only 4 ft. 6 in. These

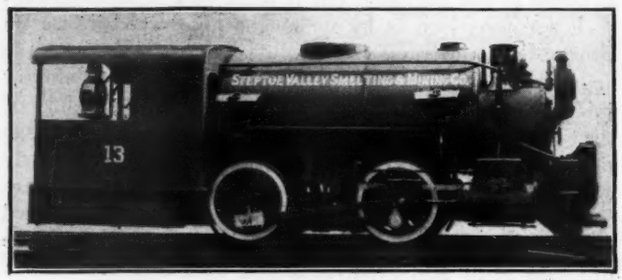


FIG. 3. 12-TON STANDARD GAGE STEAM LOCOMOTIVE

illustrations serve to show the flexibility in design; one may have a large, heavy engine on a narrow track, a light and small engine on a wide-gage track, or vice versa.

Table 1 presents comparative data on several typical steam-engine tramming systems at plants situated at widely distant points:

TABLE 1. STEAM LOCOMOTIVES COST DATA

Location of Plant	No. 1 Pittsburgh	No. 2 Connecticut	No. 3 Illinois	No. 4 Nevada	No. 5 Illinois
Gage of tracks....	23-in.	20-in.	36-in.	Standard	36-in.
Number of engines in service.	38	3	22	6	1
Weight of engines	20-21 tons 7-8 tons 3-26½ tons 3-16 tons 3-12 tons	10½ tons	9-24 tons 6-30 tons 7-49 tons	Variable up to 17 tons	11 tons
Cost of engines..	$2,500 to $4,500	$2,500	$4,500 to $7,000	(Largest) $4,000	$2,300
Durability of engines.....	Said to be satisfactory	One has been in service for 8 yr. and shows little depreciation	Will serve for 16 mos. 24 hr. per day before being overhauled	Overhauled once in two years	Has not been in service very long
Cost of engine upkeep per day....	$1.37	$0.77	$3.72	$6.84	$2.23
Coal burned per engine per day..	½ to 1½ tons	½ ton per shift	2½ tons per day	¾ ton per day	½ ton per day
Cost of coal per day (Approx.)...	$1.50	$3.17	$1.50	$5.50	$1.50
Total cost per ton hauled.....	Not available	$0.023	Not available	$0.0551	$0.029
Total cost per ton mile.....	Not available	$0.084	Not available	$0.086	$0.46

Improvements in the design of the electric motor and in its applications to haulage make the electric locomotive a close competitor of the steam.

Perhaps the principal disadvantage of the electric locomotive is its lack of complete utility as compared with the steam engine. The latter can go almost anywhere in a surface plant where two rails can be laid, while the former must always be connected with the source of electric power or must carry its power in storage batteries. For entering places where the rails are not equipped with either a trolley wire or third-rail system, special modifications of the electric locomotive have been made such as those with the "crab" attachment and the "reel" attachment. The former permits the locomotive to stand on the track served by trolley wire or third rail, and to pay out a cable and hook to reach the cars to be moved. The latter carries an electric conductor cable on a reel which can be attached to a convenient point on the trolley wire or third rail and thus furnish power to the locomotive as it proceeds along some unelectrified portion of the system.

The storage-battery motor has all the utility of the steam engine and makes no smoke nuisance, but has the disadvantage of inefficiency in the use of power, which so far has prohibited its extensive application in tramming operations.

The electric locomotive can be designed to meet almost any requirement in haulage problems, and the variations in use are numerous. Fig. 4 illustrates a 25-ton standard-gage locomotive used at the Cleveland ore docks for handling ore cars. Current at 250 volts is supplied from a third rail laid between the tracks and completely insulated. Such a locomotive costs in the neighborhood of $7,000.

Fig. 5 shows a 25-ton locomotive used for hauling 30-ton slag ladles at Great Falls, Mont. It receives 500-volt current either from a third rail at the end of the ties, or by a pantagraph trolley from an overhead wire. It carries a special compressor and compressed-air storage

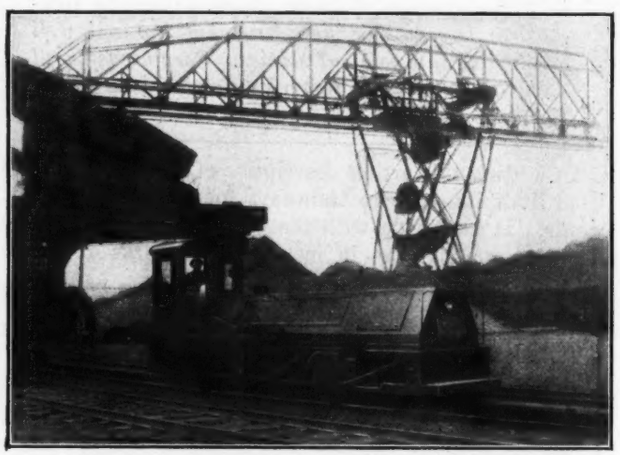


FIG. 4. 25-TON LOCOMOTIVE FOR HANDLING ORE CARS

tanks for use in dumping ladles. Such a locomotive costs about $11,500.

Fig. 6 shows an 18-ton unit for copper-smeltery work in the Southwest. It carries air-brake equipment and a special pantagraph trolley. It is build for standard gage. Its price is about $4,500.

Fig. 7 shows a 10-ton machine used at Great Falls, Mont. It is equipped for third-rail operation and carries air-brake equipment together with air equipment for operating discharge gates on specially designed hoppered cars. Such a machine costs about $4,000.

Electric locomotives using alternating current are by no means common. Fig. 8 shows a 9-ton locomotive built for a South American copper-smelting works. It is built for a 30-in. gage and carries a three-phase, 60-cycle 220-volt induction motor geared to one axle only. The approximate price of this locomotive is $2,200.

In addition to the kinds of locomotives shown in the foregoing illustrations, there are in service in metallurgical works many electric locomotives that were originally designed for mine service. Occasionally they are found equipped with cable reels and the like to enable them to work over unelectrified portions of the tramway.

An electric locomotive that seems to be coming into service particularly to meet special conditions is the storage-battery type. It is expected that its now narrow field of usefulness will considerably broaden as storage batteries are developed to a point of greater efficiency. Fig. 9 shows a 25-ton locomotive used at a Boston industrial works. It is equipped with 110-volt motors, the current being supplied by 48 cells of ironclad-type storage battery. It is equipped with hand brakes. Its cost is in the neighborhood of $4,000.

A number of mines are said to be successfully using storage-battery locomotives of small sizes for their haulage work, but as far as known they have not yet come into service in metallurgical works.

Compressed-air locomotives are not extensively used, but are employed in a few notable instances. A very large installation is in operation at Anaconda, Mont. In fact, it is said that compressed-air locomotives are used at these works more extensively and continuously than at any other works in the world. The system has about 12 mi. of standard-gage track laid with 60-lb. rails. This is all included in an area about ½ mi. square. The minimum radius of curvature is 40′, and the heaviest grade in the system is a little over 4%. The locomotive equipment consists of seventeen 15-ton engines, of the type shown in Fig. 10 and two 22-ton engines of Fig. 11 type. The machinery is in most respects the same as would be employed on a steam locomotive of the same size, the

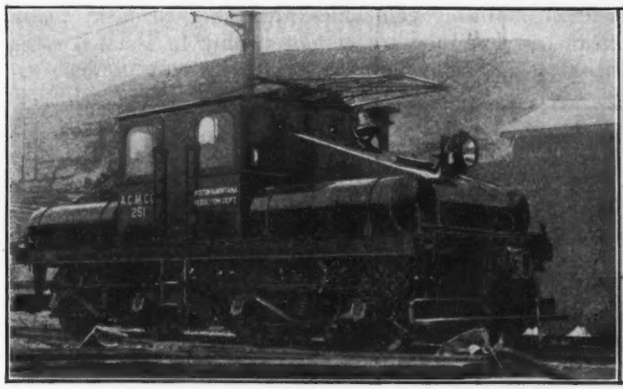


FIG. 5. 25-TON LOCOMOTIVE EQUIPPED WITH COMPRESSED-AIR TANKS

FIG. 6. 18-TON LOCOMOTIVE EQUIPPED WITH SPECIAL PANTAGRAPH TROLLEY

Figs. 5 and 6—Contrasting special types of electric locomotives

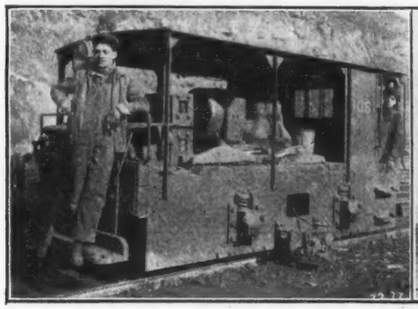


FIG. 7. 10-TON LOCOMOTIVE OF UNUSUAL DESIGN

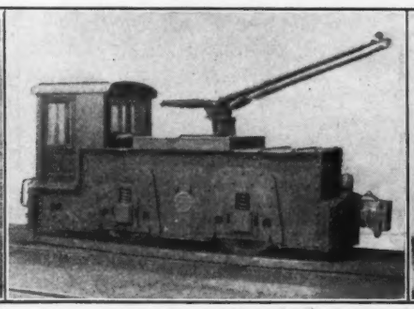


FIG. 8. 9-TON ALTERNATING-CURRENT INDUCTION MOTOR

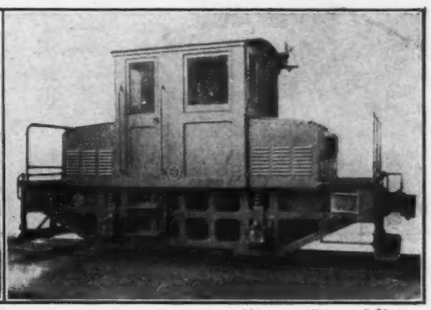


FIG. 9. 25-TON STORAGE-BATTERY LOCOMOTIVE

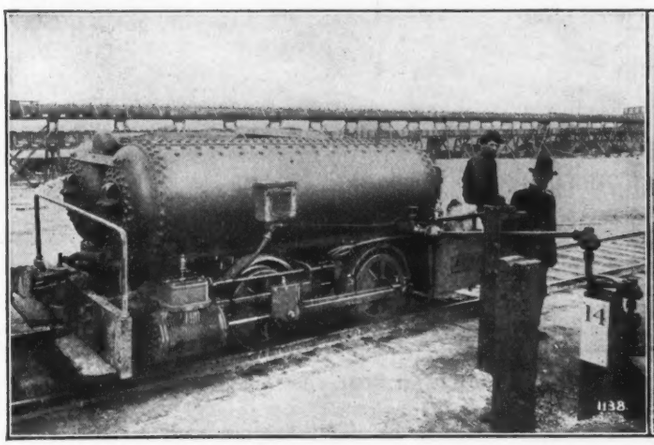


FIG. 10. 15-TON COMPRESSED-AIR LOCOMOTIVE

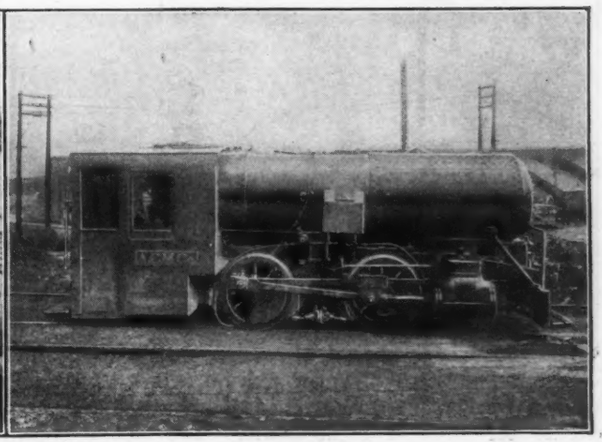


FIG. 11. 22-TON LOCOMOTIVE AND CAB

chief difference being that the cylinders are ribbed in order that they may the more rapidly absorb heat from the atmosphere, instead of being lagged to prevent the loss of heat as is the case with steam locomotives. Compressed air at 900 lb. pressure is distributed by pipes to 40 locomotive-charging stations well placed throughout the works. The air is compressed in the main power house by three 4-stage cross-compound compressors and one 3-stage triple-expansion compressor.

The service performed by these locomotives is extremely intermittent, requiring three to four hundred stops per engine per shift of eight hours. The compressed-air engine seems to be particularly adapted to such service, as it is capable of rapid starting and stopping. The principal objection to the use of the compressed-air locomotives is their low efficiency in the utilization of power. The ratio of the indicated power per cubic foot of free air used by the locomotive cylinders is about 18% of the indicated power of the compressor steam cylinders per cubic foot of free air compressed. This ratio is actually less, owing to the leakage of air from pipes and charging stations. Extreme cold weather further decreases the efficiency of the air engines just at a time when there is an increased demand for power to move frozen cars. Consequently the work performed by an air engine is considerably impaired in winter weather.

The use of the internal-combustion engine as the motive power for industrial locomotives is being developed, and a number of manufacturers have them on the market. Mining companies are using them in many instances, but they are employed only in isolated cases about metallurgical works. The first cost of such an installation should be small because each locomotive is a self-contained power plant in itself. The high efficiency of the gas engine is quite an appealing feature, especially where gasoline or engine distillate can be obtained at low prices. The nature of this type of engine, however, does not seem to make it easily adaptable to the demands of frequent starting and stopping characteristic of metallurgical works tramming service. Even if frequent starting and stopping could be perfectly accomplished by means of a clutch, it would be necessary to run the engine

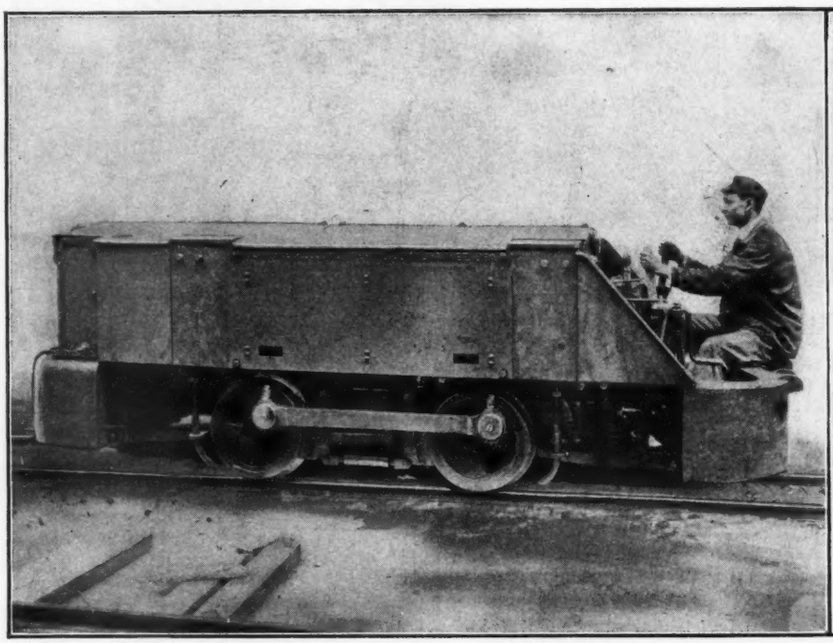


FIG. 12. GASOLINE MOTOR READY FOR SERVICE

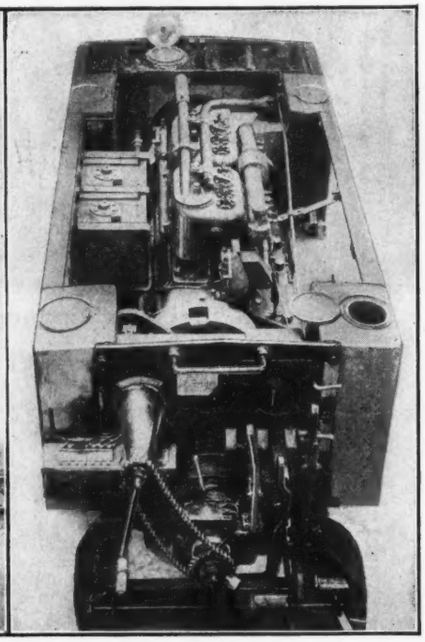


FIG. 13. MOTOR HOUSING REMOVED

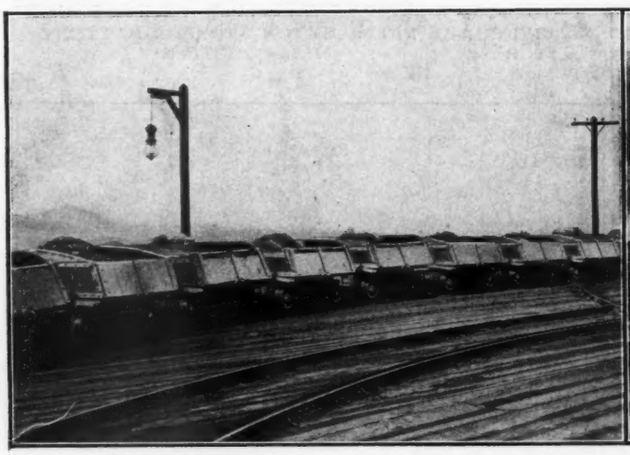


FIG. 14. SIDE-DISCHARGE FURNACE CHARGE CARS

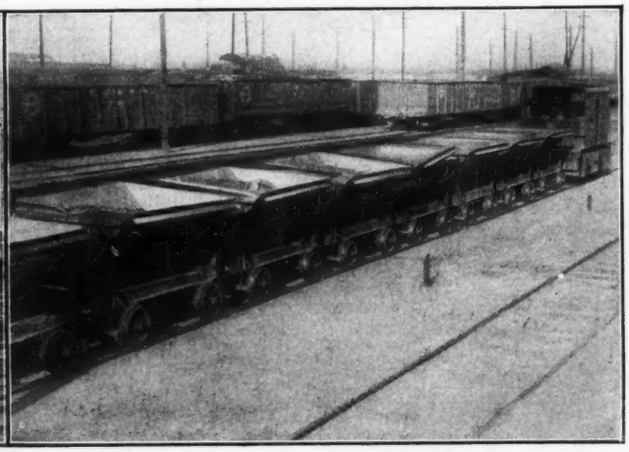


FIG. 15. ROLLING SIDE-DISCHARGE V-TYPE CAR

while idle during stops, and this method of operation would in practice undoubtedly result in the speeding of the engine, thereby wasting fuel. Figs. 12 and 13 show a gasoline locomotive with and without its housing. The latter view gives some idea of the mechanism to be kept in shape.

The tramway cars are, almost without exception, of steel construction. They must be designed for easy and rapid emptying and are therefore of the bottom-gate

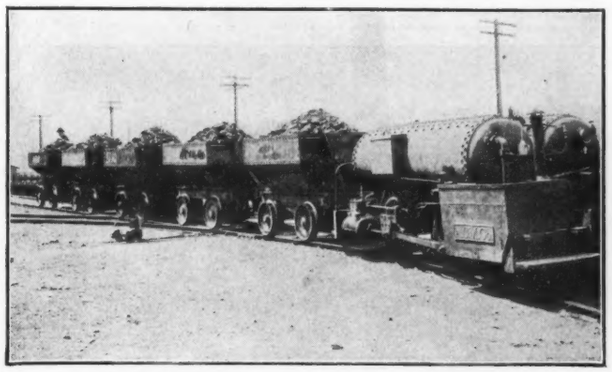


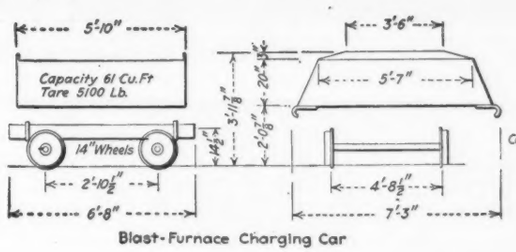
FIG. 16. BOTTOM-DISCHARGE CARS

load when rolled over as shown. It may be dumped on either side, and when in motion it is held in its upright position by means of a chain in each corner. This car is well adapted for the handling of refuse to the dump or for granular material to discharge on storage piles.

The bottom-dump cars in Fig. 16 are shown loaded with run-of-mine coal being transferred to furnace-supply hoppers. For large, coarse material such as accretions that are cleaned up around a furnace, cars with larger discharge gates must be used. A fairly satisfactory but somewhat clumsy design has large, hinged bottom gates that are wound up by means of chains and a ratchet device or simply pried up with a bar and secured by means of a catch.

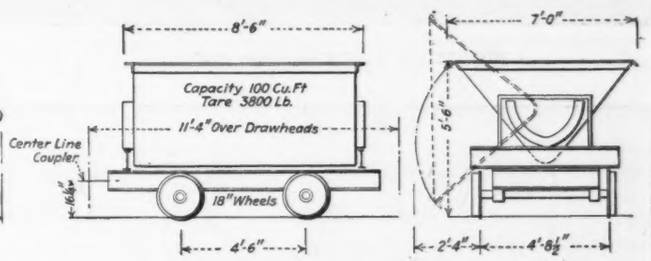
The cars shown in Figs. 15, 16 and 18 are also suitable for the transportation of fine material that is wet or that is not too fine to be blown away by the wind, such as jig and table concentrates. Another form of such car is shown by dimensional outline in Fig. 19. It is larger than the others, having a capacity for 13 tons of concentrates, and it has two discharge gates to facilitate clean discharge.

Fine dry material that makes quantities of dust requires a car that is at least partly inclosed on top. A



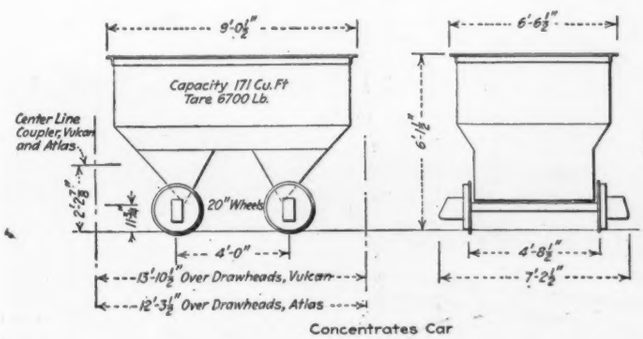
Blast-Furnace Charging Car

Fig. 17



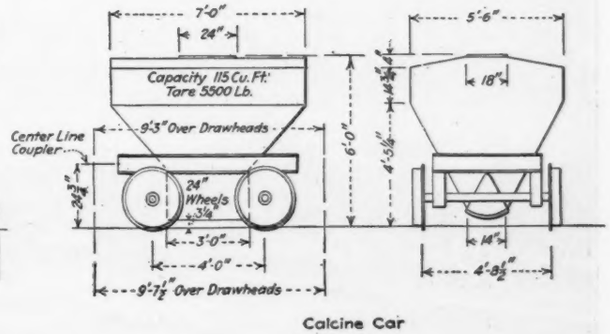
U-Type Car

Fig. 18



Concentrates Car

Fig. 19



Calcine Car

Fig. 20

FIGS. 17 TO 20. TYPES OF SMALL CARS USED IN THE OPERATION OF SMELTING WORKS

discharge, lateral-gate discharge or rolling "U" type. For lumpy material the gates are necessarily as large as design will permit. Fig. 14 shows a familiar type of side-dump furnace charge car. Such cars can be made to discharge on either side by simply raising up the opposite side. This may be accomplished by hand with the aid of a bar, but the cars shown in the illustration are tilted by means of a compressed-air cylinder suspended from a traveling trolley at the furnace. Fig. 17 is a dimensional outline of a similar car used at another works.

Figs. 15 and 18 illustrate the rolling "U" type of side-discharge car. It has no gates and discharges its

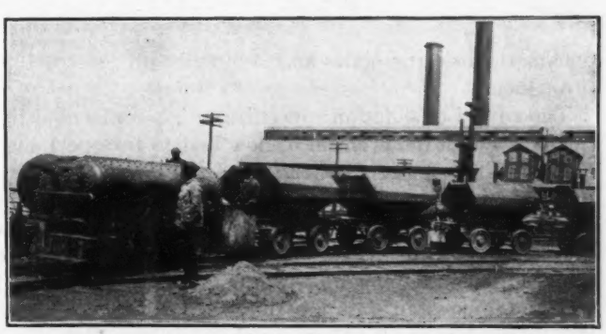


FIG. 21. CALCINE AND DUST CARS

freely moving and at the same time tightly fitting discharge gate is also essential. Such materials as dried or calcined fine concentrates and flue dust require cars of this type. Figs. 20 and 21 illustrate the commonly used form of car. The top is not entirely closed, just enough of a hole being left in the top to enable the trainmen to spot the car under the loading chute without using time to attain accuracy. Fig. 22 shows a more recent and improved design in calcine cars. It has large capacity (about 15 tons net), is equipped with air brakes and pneumatic discharge gates and is of splendid construction throughout.

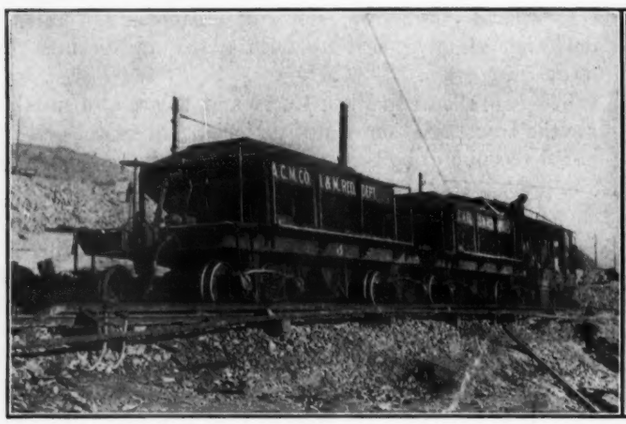


FIG. 22. 15-TON CALCINE CAR

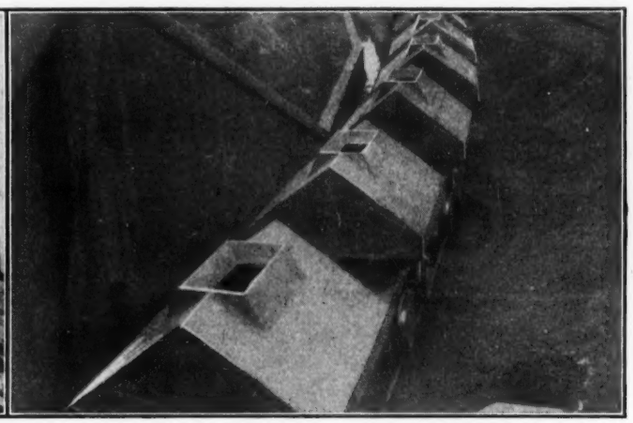


FIG. 23. REMODELED TOP OF CALCINE CAR

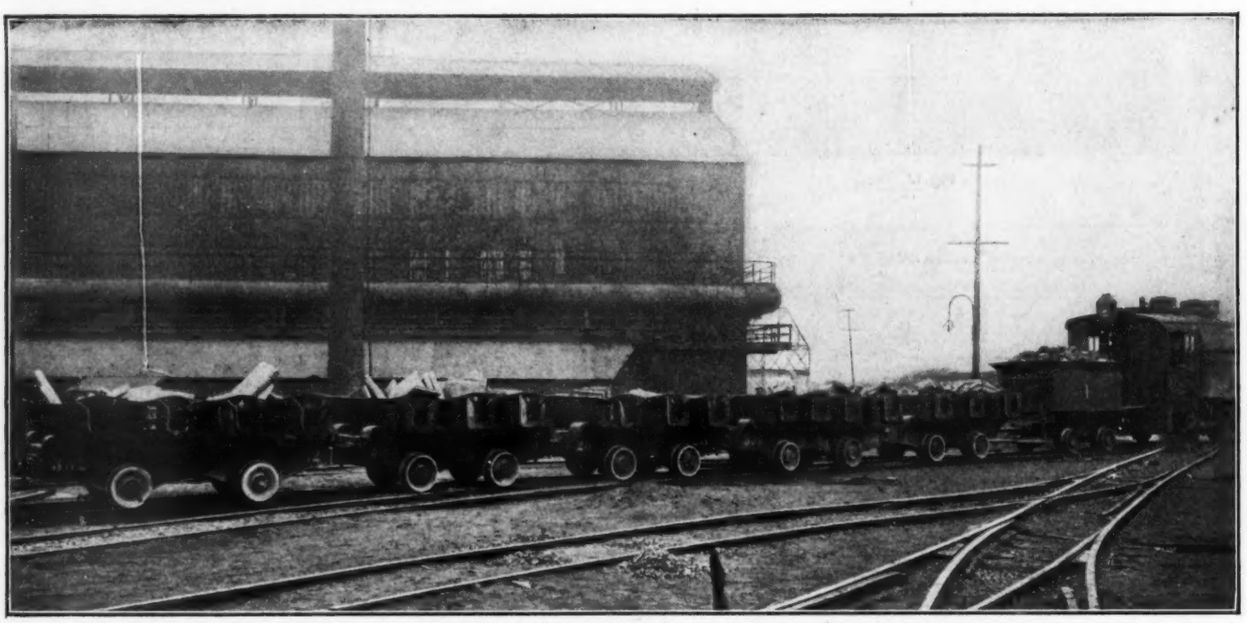


FIG. 25. OPENHEARTH CHARGING BOXES CARRIED ON SPECIAL CARS

The advent of flotation concentrates has confronted the smelteries with the problem of how best to transport such extremely fine material after it is dried or calcined. In the latter case it may have a temperature of 900° F. or more, and to say the least, it is very wild, as it will flow like water and find its way through the finest holes. In the loading and unloading of the cars dense clouds of choking fumes and dust are liberated, causing considerable discomfort to all persons in the vicinity and furthermore causing a loss of fines that is appreciable. To partly eliminate the dusting while loading the cars shown in Fig. 21, their tops were remodeled as indicated in Fig. 23. To overcome the disagreeable fumes made while dumping, the car shown in Fig. 22 has been remodeled with a new discharge gate that permits of its being telescoped by a vertically movable collar set in the closed top of the receiving bin or hopper over the smelting furnace.

Cars for the transportation of metals are usually designed to suit the particular needs of the individual service. Such cars generally take the form of heavy, massive trucks owing to the great weight and small bulk carried. A neat car designed to transport pigs of lead is shown in Fig. 24. The special charging boxes used in charging cold metals to openhearth furnaces are shown in Fig. 25. They are brought before the charging machine in trains of massive cars.

Molten smeltery products are handled in either lined or unlined vessels according to the cutting effect of the molten material on the shell of the vessel. Molten iron is handled in a brick-lined ladle car. Copper matte is handled in a somewhat similar ladle that is lined with clay or that may be unlined if made of heavy cast iron or steel

and if operated in such a way that the iron is protected from the washing effect of the incoming stream of molten metal. Fig. 26 shows sheet-iron ladles that are lined with a thin coating of clay. These ladles have a capacity of 12 tons of molten copper matte. A different type of conveyance for molten matte is a large brick-lined tank car so arranged that the tank can be tilted to transfer a charge to a converter.

Fig. 27 shows a slag ladle of 300-cu.ft. capacity. It dumps by means of compressed air. Its whole charge

FIG. 24. CARS FOR LOADS OF PIG LEAD

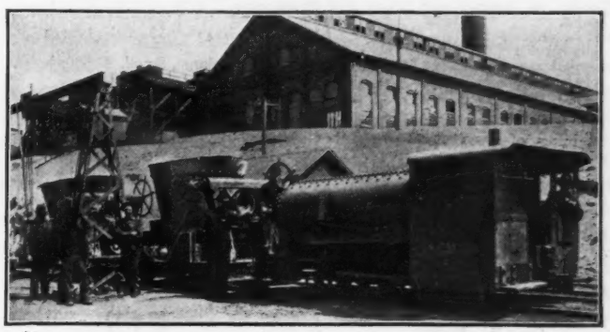


FIG. 26. LADLE CARS FOR COPPER MATTE

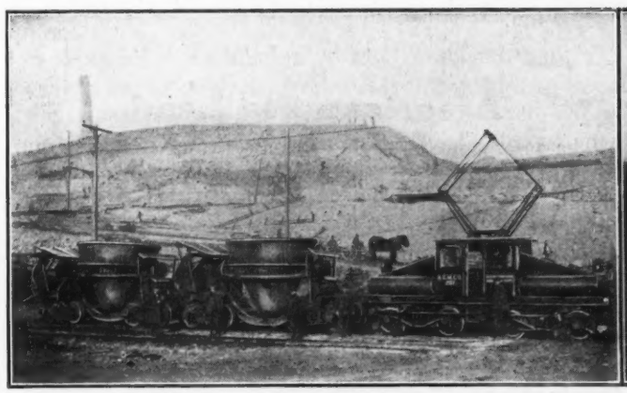


FIG. 27. 30-TON SLAG LADLES

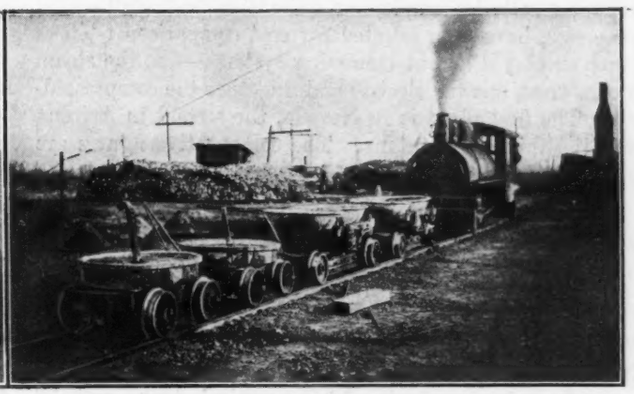


FIG. 28. SMALL BLAST-FURNACE SLAG LADLE

of 30 tons of slag can be instantly thrown over the dump, skull and all, leaving the ladle clean for the next trip.

In contrast to this large apparatus are the small pots used at a lead works, which are shown in Fig. 28.

Operating Costs of Actual Installations

There is considerable variation in the cost of tramming a ton of material in different metallurgical works on account of the widely differing requirements of the particular smelting process, as well as the size and relative location of the smelting units. The cost of tramming will always be high in works in which materials are moved in small-sized units unless, as is sometimes the case, the haul is a fixed one with steady continual traffic and little or no switching. In the latter case the work may be so well defined and so free from complications that the operating cost may be even lower per ton than in the case of a much larger and complicated tramming system. Examples Nos. 2 and 5 in Table 1 show the decided difference in cost that results from the specific service requirements of each case. In the case of No. 2 the engine duty is greater per load and per day, the service being well defined, while in the case of No. 5 the service consists of the intermittent hauling in small units of furnace products at a lead smeltery. The latter has the high cost per ton of $0.099, and this is even more accentuated when figured in terms of per ton per mile, which is $0.496. A Utah copper-smeltery tramway, on the other hand, performs the previously mentioned service of disposal of furnace products for a cost of $0.0184 per ton and $0.0368 per ton-mile. Electric locomotives are used, and the material is handled in much larger units and in daily quantity about ten times as large as that of case No. 5, Table 1. These two cases probably illustrate the extremes that may be found in operating costs.

The cost of operating a gasoline-motor system in a metallurgical works could not be obtained by the authors. The cost account of a mining plant that had one gasoline locomotive in service was available, however, and some figures have been taken from it to show the haulage cost per ton-mile as given in Table 2. The figures given

TABLE 2. GASOLINE LOCOMOTIVE COST DATA

Gage of tracks, ft	3
Weight of locomotive, tons	7
Approximate cost of locomotive	$3,900
Number of locomotives in service	1
Number of cars in train	6
Weight of empty train including locomotive, lb	25,400
Weight of loaded train including locomotive, lb	47,000
Average tons of material hauled per day	421
Average ton-miles of material hauled per day	105
Grades on haulageway, %	2 to 9
Scale of wages for train-operating labor, for 3 men	$10.80
Length of working day, hr	8

	Cost per Ton of Material	Cost per Ton-Mile Material
Actual train-operating labor	$0.0256	$0.1024
Repairs to locomotives, cars, tracks, etc	.0060	.0240
Gasoline @ $0.21 per gal	.0064	.0256
Lubricating oils @ $0.28 and $0.50 per gal	.0021	.0084
Other operating supplies	.0012	.0048
Totals	$0.0413	$0.1652

indicate a fair tramming cost, especially so when one considers the small size of the loads and the severity of the grades.

As previously stated, tramming conditions are different at all metallurgical plants, and for that reason not only is it difficult to discuss comparative efficiency of the haulage systems in use, but also it is difficult to find costs that are fairly comparable. In concluding this paper, however, the best obtainable comparison of costs will be presented. Three plants, all of which are large Western copper smelteries employing quite similar metallurgical processes, have been selected for cost comparison. These three employ different tramming systems—one the steam locomotives, one the electric and the other the compressed-air. The first plant is in Nevada, the second in Arizona and the third in Montana. The comparative figures are given in Table 3.

TABLE 3. COMPARATIVE COST DATA OF HAULAGE SYSTEMS

	Steam	Electric	Comp. Air
Gage of track	Standard	Standard	Standard
Weight of engines	Largest, 17 tons	Small 13 to 17 tons, large 26 tons	15-17 ton 2-22 ton
Weight of train loaded	11-car train, 150 tons	20-car train, 75 tons	Average 90 tons
No. of engines in daily service	Six	13 small, 2 large	12 small, 1 large
Approximate cost of one engine	Large $4,000	Small, $3,500; large, $8,000	Small, $4,500; large, $6,000
Source of power	Coal	250-volt current from steam-driven generators	900 lb. compressed air by steam and electric engines
Durability of engines	General overhauling once per two years	General overhauling once per two years	General overhauling once per year
Total tonnage hauled per day	3,955	3,120	14,124
Total tonnage per mile per day	2,530	1,773	7,570
Cost of engine upkeep per day	$6.84	$9.86	$3.60
Power cost per engine day	$0.80 (coal)	$4.52 (electricity)	$14.25 (comp. air)
Total tramming cost per ton	$0.0551	$0.0526	$0.0640
Cost per ton-mile	$0.086	$0.0926	$0.1194

Copper Queen Reduction Works

The present equipment of the Copper Queen Reduction Works, situated about a mile west of Douglas, Ariz., includes 10 blast furnaces, 3 reverberatory furnaces, 9 converter stands of the 12-ft. vertical type, and 16 MacDougall 18-ft. multiple-hearth roasters. The plant is built on a flat site, making easily possible the large additions which are contemplated. The present capacity is nearly 4,000 tons of ore or 4,500 tons of charge per day, and about 1,000 men are employed.

The average charge is made up of ores, 72.7%; concentrates, 9%; limestone, 1.5%, and secondaries, 16.8%; the mixtures being made in pits, from which the charge cars are loaded by means of steam shovels. On a basis of 4,146 tons of charge smelted per day by the entire plant, the average charge smelted per furnace day was 374.8 tons, yielding an average of 229.57 tons of bullion per day, or 20.84 tons per furnace-day. The movement of charge was at the average rate of 6.1 tons per man per shift.

The blast furnaces, of which 5 are 240x44 in. and 5 are 216x44 in., take a charge made up of approximately 82% of ore, 16% of secondaries and 2% of flux. To the charge is added 12% of coke, carrying 79.7% of fixed carbon and 18.2% of ash. The flue dust produced represents but 3.84% of the charge, the values carried being Au 0.031 oz., Ag 1.44 oz., Cu 7.30% and S 10.1%, as against Au 0.026 oz., Ag 1.25 oz., Cu 6.97% and S 12.8% average in the original charge; while the slag carries but 0.46% copper and 0.06 oz. of silver per ton. The matte produced contains Cu 37.6%, Fe 31.7% and S 25.6%, with Au 0.165 oz. and Ag 6.80 oz. per ton.

The roasters handle material consisting of concentrates 55% and crushed ore 45% of the charge; while the reverberatories treat a mixture of calcines, blast-furnace flue dust, converter flue dust and ores for fettle, comprising respectively about 80%, 19%, 0.4% and 0.6% of the total.

Oil fuel is employed to the extent of 76 bbl. per ton of charge, the feed being introduced at a temperature of 175° F. and at a pressure of 75 lb. per sq.in. The converters are basic-lined and average 43.23 tons of matte per blow, with a yield of 13.11 tons of bullion. The blast pressure employed is 13 lb. per sq.in., the consumption of air being 268,146 cu.ft. per ton of bullion.

The average analysis of ore treated by the plant is as follows: Cu, 9.13%; SiO_2, 56%; Fe, 8.1%; CaO, 1%; Al_2O_3, 8.4%; S, 6.1%; with Au, 0.075 oz. and Ag, 3.46 oz. per ton. The bullion produced assays 99.24% copper, with 0.387 oz. gold and 19.47 oz. silver per ton.

American Pig Lead

The accompanying table gives a series of analyses from authoritative, original sources, of representative American brands of pig lead at the present time. It is not, however, considered advisable to identify the brands, but simply to group them according to class.

The first class, which we have designated as "extra-fine" is a grouping of our own, including lead that is 99.97% fine or better. In certain cases these leads are produced by extra-refining, including electrolytic refining; in other cases they owe their high purity to the excellence of the ore from which they are smelted. These leads are sold for corroding, but also they fill some special needs for which lead as nearly chemically pure as possible is required.

Ordinary corroding lead is about 99.95% fine.

Ordinary desilverized lead ranges from about 99.85 to 99.91% Pb.

Common Missouri lead (southeastern) is rather uniform with 99.90 to 99.92% Pb, or about the same as ordinary desilverized. The main differences between these classes of lead are the higher copper in the Missouri and in some cases the higher antimony in the Missouri lead, which renders it slightly harder and especially adapted for the rolling of sheet that is to be used in chemical work.

RECENT ANALYSES OF AMERICAN PIG LEAD

	Extra Fine						Ordinary Corroding	Ordinary Desilverized			Common Missouri			
Silver		0.0008	0.0004		0.0005		0.0003				0.0006	0.0106		0.0070
Arsenic		none	none	0.0050	none	0.0010	0.0006		0.0003		0.0008	none		trace
Antimony		0.0130	0.0028	0.0040	0.0077	0.0100	0.0045		0.0046	0.0060	0.0056	0.0132		0.0030
Tin														
Bismuth	0.0080	0.0032	none	0.0025	0.0040	0.0100	0.0500	0.0800	0.0794	0.1200	0.0750	none		0.0030
Copper		none	0.0002	0.0010	none	0.0015	0.0006		0.0010		0.0006	0.0600	0.0800	0.0600
Iron		0.0010	0.0007		0.0010					0.0045		0.0060		0.0015
Zinc		0.0019	0.0005		0.0014			0.0040	0.0008	0.0040		none		
Cobalt and nickel		none	none		none							trace		0.0080
Lead	99.9700	99.9801	99.9941	99.9875	99.9890	99.9775	99.9440	99.9050	99.9135	99.8655	99.9174	99.9102	99.9032	99.9175

Comments and Speculations on the Metallurgy of Zinc

By W. R. Ingalls

SYNOPSIS—A discussion of the details of zinc metallurgy and some of the improvements that may be realized. Zinc burning and fume collecting are touched upon, and the merits of roasting furnaces are considered. Improvements in distilling furnaces and in retort making are suggested.

This article is aimed to be a commentary on some things that are and a speculation respecting some things that are not—yet—but may be. I am expressing myself quite frankly about a good many things and quite positively about some, and I anticipate that there will be many metallurgists who will hold different opinions. If I succeed in directing thought in certain directions, even to be contradicted and disproved, I shall at least have done all I intended.

Electrolytic Zinc

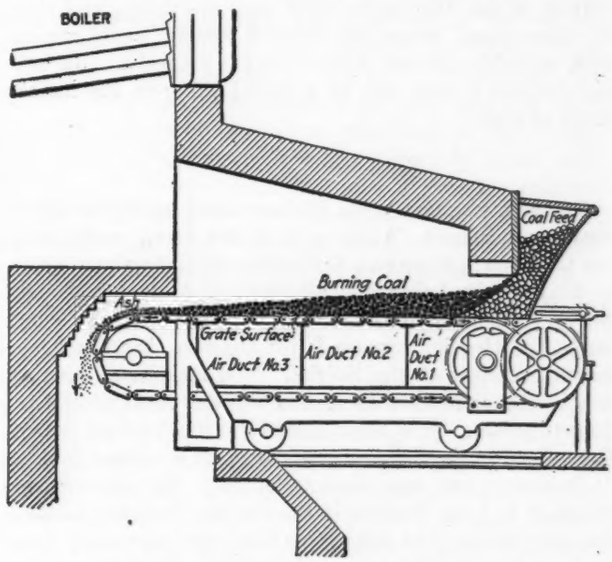
The new thing that is most engaging attention now is hydrometallurgical-electrometallurgical extraction. I believe that this new process has come to stay—that some of the concerns committed to it will be able to meet the smelters on the severest terms. But it is not going to be revolutionary. It is not going to put the smelters out of business, for it is only under favorable conditions that the process is going to be commercial. These conditions are chiefly cheap power, high silver and lead contents of the ore and good extraction of the zinc. No one company is likely to have all these at their maxima, but there will be a fair number that can strike a good general average. I put less emphasis upon direct zinc extraction than I used to, for it has become clear with progress in the art that undissolved zinc may be burned out of the residue from lixiviation, but that adds to the cost of the process as a whole, and high zinc extraction by direct leaching is to be aimed at as much as ever.

Zinc Burning

The treatment of this residue is an interesting problem that nobody has yet worked out, simply for the reason that it has had to be put aside amid more pressing problems. Given an ore that is yielding 83% of its zinc, the residue may assay about 20% Zn, but will be, perhaps, only about one-third of the weight of the original ore. The first idea is to dry this mud, mix it with fine coal and burn off the zinc on a Wetherill grate. This will give a fume that will go back into the electrolytic process and a sinter that will go to the lead-smelting furnace, the silver content going partly with the fume, partly with the sinter. Another idea is to smelt directly in a reverberatory furnace, cooling the gases therefrom and collecting the zinc fume. Still another idea is to smelt in an electric furnace, which is easy if the zinc is to be collected as oxide. With an electric furnace the volume of gas to be filtered would be at the minimum and cooling flues and filtering bags would be much smaller than in other cases. Any of these things can be worked out. It is simply a question of what is the cheapest.

Speaking of Wetherill grates, there is being a good deal of attention given to the use of them for burning off zinc simply as a method of concentration. This is an easy process where no attempt is made to collect the zinc oxide of the requisite whiteness for pigment. Our zinc smelters are doing this to win zinc from the residues discharged from their distilling furnaces. Those residues contain so much unburned coal, which is utilized on the Wetherill grates, that it is a cheap process and one that is commercially worth while. Yet it is rather a severe reflection on our distilling that it is worth while. It is something like building a fine dressing works and having a lot of scavengers recovering mineral by buddling the tailings downstream.

The weak point of the Wetherill grate is the manual labor required in running it. It is about the same now as 50 years ago, except that its dimensions have been



SECTION OF STEAM-BOILER STOKER SHOWING A CONTINUOUSLY MOVING GRATE

altered to more favorable measures and in some works it has been elevated, so that less labor is needed in handling the residuum. I wish that someone would try mechanicalizing the Wetherill grate. The process is nothing more than the burning of fine coal with a partly volatile ash. The burning of fine coal is done on several forms of traveling grate. One is shown in the accompanying illustration. I can readily imagine something of that sort being used for zinc burning.

Fume Collecting

The first thing is to cool the gases. When done as commonly, by passage through iron pipes, they have to be very long to get the necessary superficial area. Why not pass through steam boilers or arrangements like fuel economizers and recover much of the heat in useful form, besides doing the job in a more compact, more efficient plant? I understand that the River Smelting and Refin-

ing Co. is working this out at Florence, Colo. Of course there will be problems in preventing deposition of the dust and fume in the coolers, especially around the pipes, but they can be solved.

After the gases have been cooled, the next thing is to filter them. The baghouse is the conventional thing, and there is no doubt respecting its economy and efficiency. This is not to say that it cannot be beaten. Even now Simon, Buhler & Baumann are introducing an automatic, mechanical bag-filtering machine, which is being tried at Palmerton, Hillsboro and Bartlesville. It is much more compact than the ordinary baghouse and is claimed to be much more economical in operation, as certainly it ought to be if the upkeep be not too high.

Who can say what part the Cottrell system may not play? What is the reason for the difference of opinion about it at present? At the International smeltery at Miami, Ariz., it works with as near perfection as anything can. At Florence, Colo., where it is being used in connection with the zinc burning, it is an object of "cussing," I understand. Someone—I have forgotten whom—has told me, on the other hand, that for settling zinc-lead fume it is fine; that even the lead and the zinc fume can be precipitated separately. I am inclined to think that at Miami they know what they are doing, and that in other places where the Cottrell system is not acting well, probably it is not being managed properly. I believe the Cottrell system will be a useful thing in the metallurgy of zinc.

Roasting Furnaces

Our zinc smelters ought to show some enterprise about roasting furnaces. Where acid is not being made, they use the Brown, Ropp and Zellweger—all dating back nearly 20 years in design and all wasteful of fuel, although fairly economical mechanically. Where acid is being made, the Hegeler furnace is the one idea, barring a few recent examples of the Spirlet. The Hegeler furnace is nearly the same now as it was when it was introduced (about 1882). It is built larger and more substantially, but otherwise the improvements are only in minor details. It is clumsy and only semimechanical. Its intermittent rabbling is a bad feature if the ore that is being roasted has any tendency to sinter. In that case there may have to be a considerable gang of men all the time on the job of chiseling off the hearths, which is not good either for the hearth or for the gas-strength or the cost sheet. The furnace is of rather staggering first cost. A complete unit—gas-producer, furnace, house, dust-catcher, chimney, etc.—costs about $125,000. This roasts about 50 tons of ore per day if it be good; maybe only 40 tons if it be sintery.

The Spirlet is a good furnace, well worth trying. It comes in small units, which often is an advantage. It is economical of fuel and gives a strong gas and continual rabbling of the ore. However, it also is costly; that is, in proportion to its capacity.

The Merton is a furnace that has not received the attention it deserves. In principle it is all right, but there may be some mechanical details that will have to be tested by experience. So far as I know, only one set of Merton furnaces has ever been erected at a zinc works on this continent, and at it they were run only a few days, after which the works failed; but Mr. Jones has put them in at the new smeltery in Siberia. This ought to be a particularly good furnace for those smelters who do not want to make acid.

Another furnace that should receive very respectful attention is the Wedge, which is illustrated elsewhere in this issue. The Wedge is one of the most successful of all furnaces for roasting copper and lead ores. It is now being used widely for roasting zinc ores as preliminary to lixiviation. The task asked of it for that purpose is not quite so severe as roasting preliminary to distillation, but I fancy the latter can be done and the Wedge furnace people, who know their business, would be glad to help the thing along and would see it through. Some of our zinc smelters ought to have the nerve to try it and stay with it.

The ideal blende-roasting furnace has continuous rabbling, low hearths, thick walls, air-cooled stirring mechanism and a return of the hot air to the lowest hearth. If heat can be recuperated from the chimney gases and returned to the furnace, so much the better perhaps. The correct theory is to conserve heat in the first place, and in the second place to take it away from parts of the furnace where there is a surplus and put it back in parts where there is a deficiency. I have seen Hegeler furnaces operated with preheated air and getting too hot on some of the hearths, so the preheating had to be cut out; but manifestly the system was radically wrong when that had to be done and when coal to the amount of 20 to 25% of the weight of the ore still had to be burned. I believe that the correctly designed blende-roasting furnace will desulphurize ore to 1% S with the use of only 5% coal, perhaps less. Even now the Delplace and Spirlet furnaces do it with less than 10%. Of course I have good coal, 7,000 calories or upward, in mind. When lump blende is burned in a stall, the combustion ceases in about 48 hr. It is not sufficiently active to overcome the insweep of excess air and the loss of heat generally. The old Gerstenhöfer kilns used to burn fine blende down to about 5% S autogenously. They were built in blocks and had only one side and a small top exposed, so conservation of heat was good and air supply was well controlled.

Distillation Furnaces

In the matter of distillation furnaces there is as much uniformity among American smelteries as there is with respect to roasting furnaces. At Pueblo, Colo., there are some Overpelt-Rhenish furnaces. At Peru and Depue, Ill., the furnaces are Siemens-Belgian. At Palmerton, Penn., are the only examples of counter-current recuperative furnaces, the design of their laboratory and superior structure being along Belgian lines. Everywhere else the furnaces of the United States are Hegeler-Belgians[1], designed either for producer-gas or natural-gas firing, with the necessary modifications according to the fuel. With the Hegeler-Belgians fired by producer gas, in most cases the products of combustion are conducted through properly designed steam boilers on their way to the chimney. When there is a demand in the plant for a great deal of power, as at Peru, La Salle and Donora, this is a very good method of heat recuperation. When the furnace is credited with the coal equivalent of steam generated, the consumption of coal for smelting is reduced to a relatively low figure, but I question the validity of some of the

[1]Except, of course, some relicts of the old simple Belgians that survived before the outbreak of the war and those that have since been built for ephemeral operation.

phenomenally low figures that are talked about. In order to dispose of the combustion gases by means of a chimney, a certain minimum temperature is required. If in reducing them to that minimum temperature the surplus heat is recuperated either in the form of steam or in the form of preheated air to be returned to the furnace itself, assuming losses by radiation, etc., to be the same in each case, the thermal balance is the same; that is, one method is as good as the other and the determinative factors will be first cost of plant and other things. As a general principle, however, it is best to get the maximum work out of a particular furnace, machine or process and not to try to do two or three different things imperfectly at the same time.

In Europe the Rhenish furnace of one variety or another is becoming the predominant type. The sharp cleavage between European and American practices in distillation furnaces is remarkable. The Europeans have never been interested in our Hegeler-Belgians, while we have never built any Rhenish furnaces except those at Pueblo, which were erected by Overpelt engineers, the firm of Beer, Sondheimer & Co. being at that time interested in the Pueblo plant. Some of our most experienced metallurgists who have been connected with the administration of the Pueblo plant have conceived a strong prejudice against its furnaces. Nevertheless, I am convinced that the Rhenish furnace should receive more respectful consideration by some of our smelters who are operating plants where conditions are favorable to it. Among other things, we ought not to be so complacent about a loss of 2% of zinc, or so, because the taking off of prolongs for our three daily drawings of spelter does not comport with our labor conditions.

The dream of a good many zinc metallurgists for 50 years was to manage to smelt zinc ore in a blast furnace. We are pretty sure now that it cannot be done—that it involves things that are contrary to a law of nature. The next best thing, probably, would be to smelt in vertical retorts; that is, to turn the retorts of our present furnaces from their approximately horizontal position to the vertical. This would greatly reduce the labor of the maneuver—the discharging and charging of the retorts—which is the principal part of the labor requirement in distillation. Instead of ore having to be thrown into a small cylinder, a job that requires extraordinary dexterity, the charge would simply be dropped in; and similarly the residue would be dropped out instead of having to be raked or blown out.

Vertical retorts were the very prototypes of our furnaces (see the primitive Chinese furnaces, the early English furnaces and the Carinthian furnace, the last being a contemporary of the first Silesian furnace). A good many metallurgists tried to modernize the Carinthian furnace, increasing the size of the retorts, improving the arrangement, etc., but nothing useful was accomplished. The charge gave trouble by hanging in the retorts, the gas and vapor could not escape properly, etc. The old difficulties have been completely overcome and, moreover, the reduction of charge has been made a continuous process by the Roitzheim-Remy furnace at Hamborn (Westphalia) if we may rely upon Mr. Liebig[2], and certainly he is a high authority. Unfortunately his article does not give a drawing of the furnace. He describes mechanical features and the method of gas firing, general operation, etc., but not the thing we should most like to know about; namely, the connection of the condenser to the retort. In some of the Roitzheim patent specifications a series of side outlets from the retort by means of upwardly slanting holes—an entirely logical arrangement—are shown. Is this a feature of the furnace at Hamborn? Anyway, it may be accepted from Mr. Liebig that the continuous smelting of zinc ore in a vertical retort is an accomplished fact, and the development of the Roitzheim-Remy furnace should be watched carefully.

[2]"Metall und Erz," Mar. 22, 1916.

Briquetting

One of the great problems that confront the zinc smelter is the distillation of excessively fine ore, such as he gets from the flotation mills. Excessively fine stuff is not the best material with which to fill a retort. It is bulky, reducing the retort capacity. The gas and vapor cannot readily get out of it. The heat is checked in getting into it. The time is coming when flotation concentrate will be the smelter's main supply of ore, and then he will have to master the problem of it. (Incidentally, this thing does not bother his electrolytic rival, except in the matter of roasting, which is common to both.)

One of the things that ought to be thought about is briquetting. Parker C. Choate has lately been doing some work on this subject, especially with a view to the direct decomposition of zinc sulphide by lime. The chemistry of that reaction is not new. Prost long ago showed that lime decomposition of zinc sulphide took place about as easily as carbon reduction of zinc oxide. This idea does not, however, appeal favorably to the zinc smelter. In the first place he wants to free his sulphur in the easiest possible way for sulphuric-acid manufacture, and in the second place he wants to smelt his retort residue for silver and lead and does not want to have it messed up with calcium sulphide. But Choate's main idea is to make a very dense briquette under great pressure, making a mechanical compound of ore and carbon that will have practically the physical properties of an artificial mineral, which he does by a process of his invention, and there may be something in that which is worth trying. The intimate contact of ore and reduction material, the good heat-conducting property of the compound and the ability to get a suitable granularity of charge, even out of excessively fine material, embody principles that are correct.

The preparation of briquettes merely for charging in the form of cartridges, the revival of an ancient idea that is now having some vogue, is an entirely different affair. There are some good features about the notion of charging in that way, but the difficulty is to get the charges into the retort after it has crusted up with slag.

Retorts

American smelters should give much more attention than they do to the manufacture of their retorts. Consider first the matter of clay supply. Everybody uses the St. Louis clay. Good clay is getting scarcer and scarcer and the quality of what is available is running down. Who is doing anything to find new clay supplies? Surely there are in this great country deposits of other clays that are suitable for retort manufacture, and probably there are a good many that are better than the St. Louis clay if somebody would only try to find them. The St. Louis clay is not such a wonderful product anyhow. We keep on using it because it is plastic, because all the

pottery men are used to it and because it has been proved by long experience to be well adapted to making retorts for relatively gentle use. But if we should drive our furnaces up to 1,550° C., as the Europeans do, our retorts would fall down (and maybe our furnaces also), wherefore we conduct operations more moderately and are now thinking about turning the retort residues over to Wetherill grate burners to expel the zinc that the distillers have failed to do.

But taking the clay that we have, we are not very careful in the making of the retorts. Nowadays everybody of consequence uses the Dor hydraulic press (or one of its derivatives), which we borrowed from Europe. The standard installation comprised a pug-mill, a hammering machine and the press. Some of our smelters, in their desire to cut out "unnecessary frills," have discarded the hammering machine. They cut off a sausage from the pug-mill and dump it into the press. The sausage is not dense, it may be decidedly imperfect, but in it goes with its included air, which within the confines of the press is bound to concentrate, under the pressure, in bubbles and blisters. Nobody is going to make good retorts in that way. The hammering machine, or its equivalent, the kneading machine (preferred by some), is an essential part of the plant, in order to make dense blocks of the proper shape for the press.

In the seasoning rooms, heated by steam pipes under the grated floor, there is moisture to be gradually eliminated. For this there is required a certain supply of air and there must be means for the exit of what is introduced, the moisture going with it. Some of the more modern potteries are designed with a recognition of this simple idea, but a good many exist that are constructed on the principles of a barn. A thermometer for temperature control is generally to be observed, but rarely a hygrometer for control of the humidity. Yet the cigar and tobacco men use them. We shall see the time when we shall make and use our retorts without so much guesswork.

Prereduction

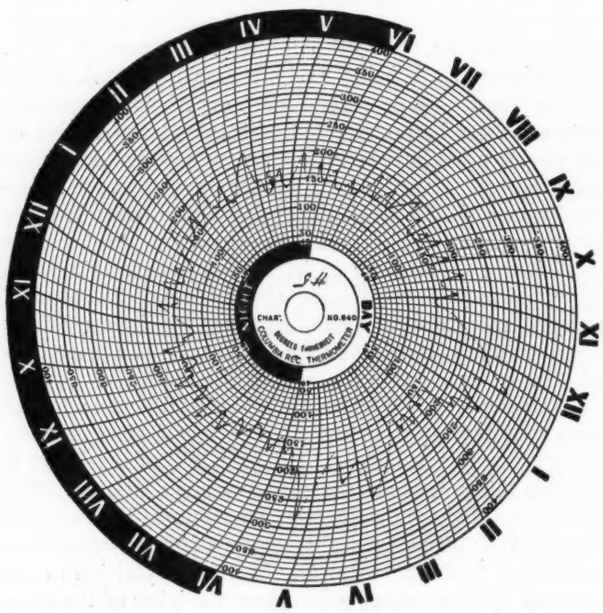
It seems to me that Mr. de Saulles struck an important line when he tried prereduction of his charge before putting it into the retort. The distillation of zinc ore is a stage process. First come off the hydrocarbons of the coal, then the metallic oxides other than zinc begin to be reduced, giving off carbon dioxide as a reduction product, which reoxidizes zinc when the reduction of zinc oxide begins. This is a powerful influence in the formation of blue powder, which occurs chiefly in the early period of distillation. It is not so fatal in the ordinary method of smelting, just by reason of its intermittency, as it is in any continuous process. In the latter it is essential that the preliminary reduction be performed in a separate furnace if excessive blue powder is to be avoided, and electric zinc smelters found that out, just as Salgués indicated they would many years ago. Also, let it be noted that in the Roitzheim-Remy continuous furnace, to which reference has been made, the charge is said to be preheated, by which I assume that prereduction is meant. Now, while that is not so crucial a matter in ordinary, intermittent smelting, it is nevertheless a matter of considerable moment, as Mr. de Saulles has shown. This idea is worth following.

I have elsewhere discussed the troubles that zinc smelters have been experiencing with regard to the sampling of their spelter slabs. By reason of the nature of their process they cannot insure uniformity of product when they draw spelter into small kettles and cast directly from them. European smelters use large mixing kettles. We have got to do something like that or else remelt the spelter in a reverberatory furnace, as the sheet-zinc rollers do, and recast from that. This is a subject to which American zinc smelters are bound to give attention. The electrolytic producer is free from this problem, for he has to remelt his cathodes anyhow.

The Regulation of Blast Furnace Feeding

By L. D. Anderson*

In the feeding of practically all types of blast furnaces regularity is a *sine qua non* if good work is to be obtained. This is particularly true of silver-lead furnaces. There is considerable temptation for feeders to fill up furnaces quite high and then sit or lie down for a good long rest. In order to prevent the irregularities resulting from this practice, many expedients have been resorted to by various superintendents.



A TEMPERATURE RECORD SHOWING THE VARIATIONS CAUSED BY FEEDING

Perhaps as common a means of watching the furnace work as any is the observation of the blower revolutions when the blowers are steam-driven and pressure is maintained by speed variations. If furnaces are allowed to get unduly low, the blowers will speed up, and vice versa. Hourly or half-hourly records of blower revolutions are often enlightening as to what is going on at the furnaces. As a measure of the regularity of feeding, however, they are not quite satisfactory, for a change in the character of the charge from coarse to fine will slow down the blowers, and so on. Knowing that the charge columns are maintained at the correct heights, the blower revolutions are then really indicators of the character of charge being fed.

When the charge cars are electrically propelled, a recording ammeter on the tramway circuit will show just

*Superintendent, United States Smelting Co., Midvale, Utah.

how frequently charges were delivered. Electrical devices have been used that make marks on revolving charts every time charges are dropped. One of these on each furnace is better than the ammeter on the whole circuit, as with such an installation each individual furnace can be kept track of.

One drawback to these devices is that they do not give feeders proper opportunities for exercising their judgments. In the effort to make regular records the slow or the fast running of the furnaces may be disregarded, and instead of charges being dropped as needed by the furnaces, they may be dropped at such times as will appear well on the recording charts.

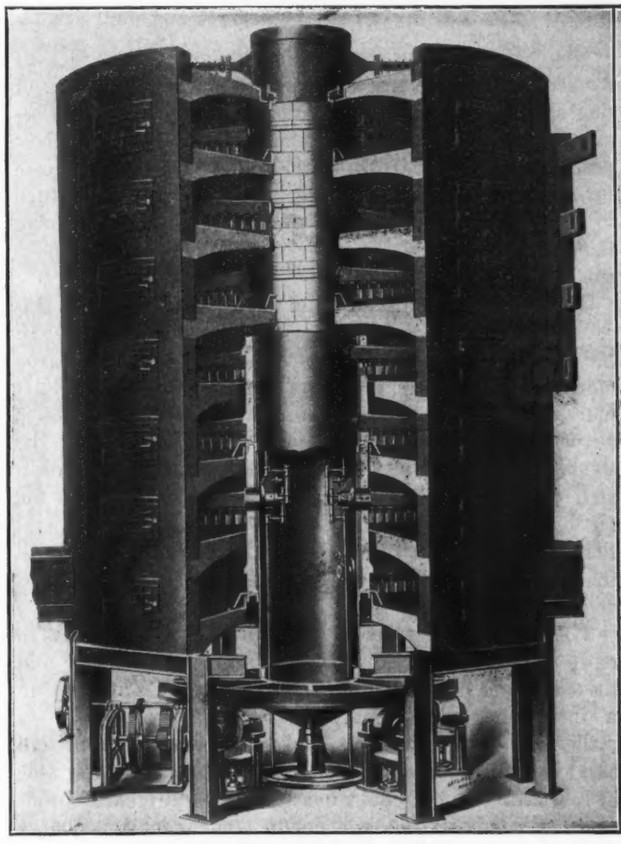
To overcome the objections to the systems of recording furnace feeding described, a new one has lately been devised. This is the use of a recording thermometer in the blast-furnace downtake. Every time a charge is dropped, there will be a sudden drop in the temperature of the downtake gases. These drops will make sharp indentations on the curve of temperature. With such a chart before him, the blast-furnace superintendent will have a clear record of exactly when charges were dropped and whether they were put in at the proper times as indicated by the general temperatures of the furnace tops. In addition the temperature record sheds much light on the actual performance of the furnaces themselves. "Hot tops" and "cold tops" are at best rather vague terms. Far better are true records of actual temperatures. If to these are added also records of blower revolutions, slag and matte analyses, and tonnages, the experienced blast-furnace man should have close control upon his operations.

Wedge Roasting Furnaces for Lead Matte and Zinc Ores

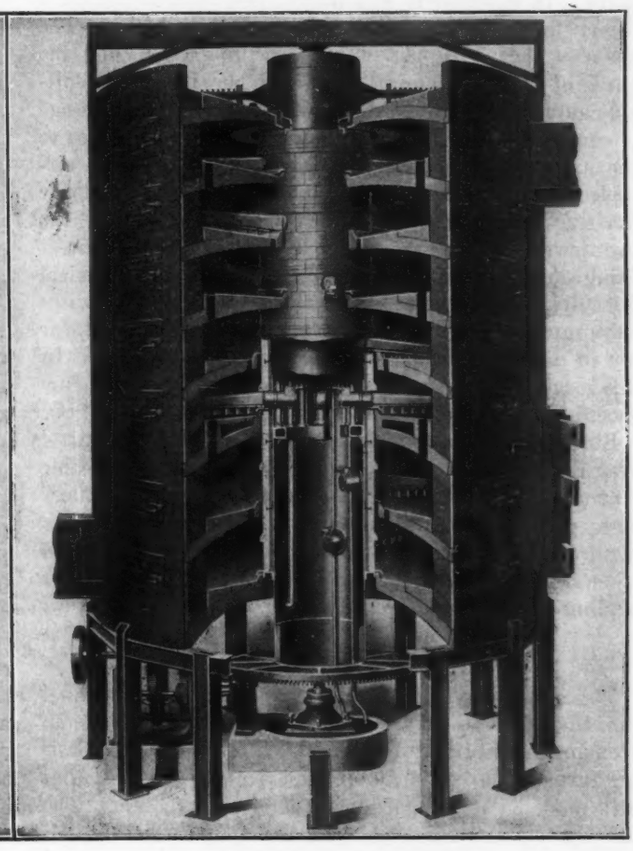
In the last five or six years, besides the general use to which multiple-hearth furnaces of the Wedge type have been applied, two new fields have been invaded—the pre-roasting of lead matte and of zinc ores. The following information regarding these applications is supplied by the manufacturers, the Wedge Mechanical Furnace Co., of Greenwich Point, Philadelphia, Penn.

Avoids Fusion of Lead Matte

Prior to the use of the Wedge roaster, lead matte was roasted either in hand furnaces or in mechanical furnaces of the single-hearth type. Both the hand and the mechanical furnaces required the use of fuel, from 10 to 12% being average practice. In the Wedge multiple-hearth lead-matte roaster the heat units are conserved, but the temperature is kept within control and fusion is avoided; in consequence, lead matte is pre-roasted in this furnace without the use of extraneous fuel, the operation being finished on the Dwight & Lloyd sintering machine.



WEDGE LEAD ROASTER



WEDGE ZINC ROASTER

Close Temperature Control Needed for Zinc Ores

In 1910-11 a modification of the Wedge furnace was tested for the roasting of zinc ores and concentrates. This did not prove satisfactory either to the operator or to the manufacturer. However, work on the problem was continued, with the result that today there are about 30 Wedge roasters, either in operation or being constructed for the purpose of roasting zinc ores. In the zinc roaster, the manufacturer utilized the experience gained in other

lines—having to do with high temperatures, also with the conservation of heat units, and maintaining at the same time all conditions under control. As has been known, a large percentage of zinc ores and concentrates will, under proper furnace conditions, auto-roast to a certain sulphur content. This content will vary with the ore being roasted, but averages around 3 to 5%. To eliminate this last 3 to 5% of sulphur, where it was desired to use all the sulphur gases for acid production, naturally resulted in the use of various muffle-fired furnaces. Since greater economy in fuel can be obtained by direct firing, it seemed desirable to avoid, as far as possible, the use of muffles. This idea has been carried out in the Wedge zinc roaster.

In the five upper hearths the ore is auto-roasted. Between the fifth and sixth hearths there is one muffle which assists in eliminating the sulphur for the production of acid to what appears to be the lowest commercial point. In addition to this muffle, provision is made for direct firing on the sixth and seventh hearths. The gases of the five upper hearths are up-drafted, and the gases of the two lower hearths are down-drafted, suitable automatically luted dropholes preventing the passage of combustion gases from the lower part of the furnace to the upper. The arms of the five upper hearths are air-cooled, and the warm air from these arms is used for drafting the upper part of the furnace. The arms of the two lower hearths are water-cooled, permitting direct firing on these hearths, without any serious mechanical difficulty with the arms. The furnace is also built without a muffle, and direct-fired on the two lower hearths, for use in districts where the sulphur gases are wasted. In this roaster the combustion gases pass up through the furnace, being taken off at the top.

Since conditions obtaining in the roaster, with control over the quantity of air admitted, and with reasonable control of temperatures, do not favor the formation of any large percentage of sulphates, the excessive temperature required for breaking up the sulphate, as experienced in other types of roasters, is avoided, being another factor tending toward economy of fuel.

General Features of Furnace Construction

The accompanying illustrations show in part-sectional elevation the two types of furnaces under discussion. So many descriptions of the Wedge multiple-hearth roasting furnaces have been published from time to time that little need be said regarding general construction. The striking characteristic is the central shaft, which is hollow, open at top and bottom, about 5 ft. in diameter and insulated with fireclay tile, the construction being similar to the brick-lined shell of the roaster. This construction is desirable, for several reasons. Primarily it eliminates a disturbing cooling medium in the heart of a furnace; it makes possible the fastening of the arms on the inside of the shaft, where the locking device is not exposed to the heat or gases of the furnace, and is accessible, even in a hot furnace; further, it permits of providing independent air- or water-pipe connections to each arm, with positive control over the quantity of air or water admitted to each arm, thus making it possible to have some of the arms water-cooled and some air-cooled. The entire construction lends itself readily to various modifications which practice has indicated are desirable for roasting ores of different character.

Among the various applications to which the Wedge multiple-hearth furnaces have been adapted are: Roasting of gold ores for cyaniding; partial roasting of copper ores for reverberatory treatment; drying and preheating of concentrates for reverberatoy furnaces; sulphatizing copper ores for leaching; roasting cupriferous pyrite for the production of a rich gas to be used in the production of sulphuric acid for the leaching process (furnaces of this type are in commercial operation, delivering a sulphur gas that will average above 13% SO_2, with a negligible quantity of SO_3); roasting of pyrrhotite ores without the use of fuel; dead-roasting iron ores; roasting in connection with the chloridizing treatment of silver ores and of copper ores. In fact, there is hardly any type of roasting plant in which these furnaces have not found application.

Blast-Furnace Slag Shells

By Curtis Pigott*

One of the recent noticeable changes in practice of American lead smelters is the abandonment of the use of slag shells on the charge. Practically ever since the beginning of lead smelting in the United States, the best practice has been to allow the filled slag pots to cool for a few minutes before being tapped and then to return to the charge all or a large portion of the shell of slag that remains in the pot after the molten slag has been run to waste.

There are three distinct and separate reasons for this return of slag shells to the blast-furnace charge. In the first place these shells are coarse and keep the charge more open. Secondly, they have been smelted once and are more easily fusible than any similar mixture of unsmelted ore and flux. Thirdly, and most important of all, the shells and bottoms, which are left in the slag pot, contain any small shots of matte or lead that have escaped the settler, besides containing a considerable amount of metal that has been carried into the slag and is combined with the slag, but tends to concentrate to a greater or less degree in the shells.

The physical nature of blast-furnace charges has a most important bearing upon the speed of smelting and the condition of the shaft of the furnace. Until within a few years blast-furnace charges were composed of rather fine carbonate ores and a fine-roasted ore from hand reverberatories or other roasters that were only able to roast the ore, but could not sinter it and make a product that was coarse enough not to tend to make a charge that was very fine physically. Thus it was necessary to add some coarser material to the furnace to make the charge more permeable to the blast and so to increase the speed of smelting. Slag shells accomplished this work very well, as they were broken to any desired size and were easily melted again in the furnace. With the use of Dwight-Lloyd sintering machines the majority of smelting plants have been able to produce a roast that is as coarse as slag shells and almost as easily melted, owing to the incipient fusion of the sinter on the machines.

As to the carrying off of drops of matte and lead in the slag, it is rare today to find a large smeltery that is exposed to the loss of matte and lead through the carrying away of shots in the slag. This has been accomplished

*Metallurgist, in charge of blast furnaces, United States Smelting Co., Midvale, Utah.

by the use of larger forehearths and a more careful handling of slag and matte. It has been generally agreed, however, that the shells from the slag pots will contain about half again as much value as the slag from which they came, and this fact has been one of the determining factors in favor of the use of slag shells.

The idea of running lead blast furnaces without the use of returned slag shells on the charge has been considered in several different ways by the managements of different companies. One of the large producers started its smeltery with the assumption that the use of slag shells was not economical. Another plant spent several months determining the effect of eliminating slag shells from the charge. The management of this smeltery finally discontinued the use of slag shells after it had doubled its settler capacity, putting in two forehearths where there had been but one before. With better settling arrangements this smeltery could save enough fuel and value to more than pay for the loss in the shells and the added expense of the extra forehearth. This plant found that the use of slag shells called for about 1% more coke.

Another large smeltery in the West deliberately took the shells off the charge of one furnace and then sampled and assayed the shells from this furnace and compared the results with the assay of shells from furnaces using slag shells on the charge. The results were a great surprise, as the shells from the furnace using no slag shells contained very little more value than the run of the slag, while the shells from the furnaces using shells contained two or three times as much metal as the run of the slag. This experiment, after being tried repeatedly, convinced the management that the shells contained somewhat higher values than the wasted slag, but that these values were not reclaimed by resmelting but ran through the furnace unaltered, and in fact, tended to concentrate in the shells. It was concluded that, with the use of slag shells the shells reclaimed would undoubtedly seem to be very valuable, but that when the shells were taken off the charge, the shells in the slag pots immediately lost their comparatively high metal content and contained very little more metal than the molten slag in the pot. Each of the experiments was continued for several weeks, so that the results would give a normal average and eliminate any peculiar condition or freak sample. In the first experiment the shells from the furnace with no shells on the charge assayed 0.65 oz. Ag, 0.23% Cu, 0.75% Pb and 1.9% S. At the same time shells were sampled from the other furnaces that carried shells on the charge. These shells assayed 1.8 oz. Ag, 0.25% Cu, 2.33% Pb and 1.7% S. The second experiment gave shells as follows:

COMPARISON OF SLAG SHELLS

	Ag Oz.	Cu, %	Pb, %	S, %
No shells on charge	1.0	0.15	1.60	1.3
Shells on charge	3.4	0.50	2.40	1.7

The third experiment was conducted with the idea of assaying the bottoms of the shells separately from the sides and the samples assayed as follows:

VARIATIONS OF SHELLS AND BOTTOMS

	Ag Oz.	Cu, %	Pb, %	S, %
No Shells on the Charge				
Shells	1.1	0.20	1.5	1.4
Bottoms	1.6	0.30	1.6	1.4
Shells on the Charge				
Shells	3.8	0.32	3.6	1.3
Bottoms	2.0	0.40	3.3	1.5

These three experiments all point to the fact that the values in the shells are not released by smelting, but tend to concentrate in the shells if they are charged back to the furnace again.

In conclusion it must be borne in mind that there is a considerable saving to be effected by the abandonment of the use of slag shells. In the first place the labor of breaking up the shell and then feeding it back to the furnace is quite an item and in some large smelters requires three or four men a shift for four furnaces. Also the saving in fuel is fairly large. Contrary to the old idea that a certain percentage of shells can be added to a charge and not increase the fuel requirements, the specific heat required to melt the shells certainly does consume fuel. In other words, it is found that furnaces that require 13% coke with shells on the charge do better work with 12% coke and no shells. This point of 1% less coke has been mentioned, but to some readers it may not be clear that it is the difference between 12% and 13%, or an actual final saving of about 8% fuel.

Ferromanganese Smelting in Electric Furnaces

By Henry O. Marcy*

"What is believed to be the first lot of commercial electric-smelted ferromanganese ever produced has been turned out by the Alabama Power Co., by the new hydro-electric furnace." So read a dispatch from Anniston, Ala., to the *Boston Evening Transcript* of Aug. 16. As a matter of fact, William H. Rowe, of New Hampshire, has been producing electrically smelted ferromanganese, tungsten and other alloys at Tacoma, Wash., for about a year. Since the manganese deposits of western Washington are little known, an account of them is of interest.

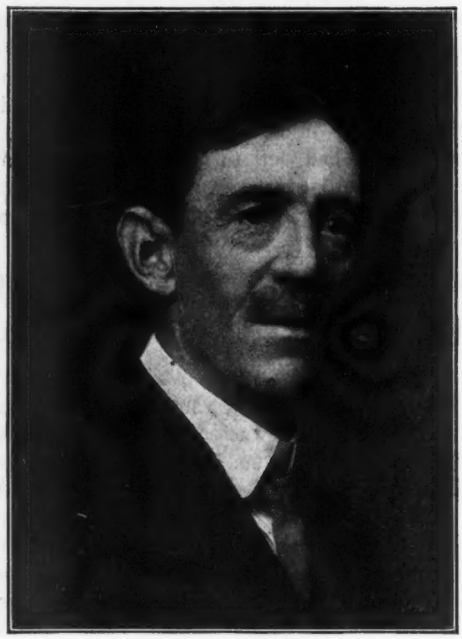
They occur near Stair Case on the Skokomish River, in Mason County, where the southeasterly flowing stream has cut through the foothills bordering the Olympian Range of mountains to the north. Here the discovery of native copper in minute seams had been made in many places, the assay rarely exceeding 2 to 3% copper. In the belief that the assays would show improved copper content with depth, prospecting has been carried on in places to a depth of about 200 ft. In this the mine owners were disappointed, but assays revealed the chief ore constituent to be a silicate of manganese and iron with traces of copper, the manganese running from 20 to 50%.

In spite of preliminary discouragement, Mr. Rowe experimented with an electric furnace in which a temperature of 4,000° F. is easily reached and eventually this solved a difficult smelting problem. Having contracted for cheap hydro-electric power at Tacoma, east of the ore deposits, a $50,000 furnace was erected there at Tidewater, where the ore is delivered at econominal rates.

The Olympian manganese deposits are now said to be capable of the production of immense quantities of high-grade ore, the demand alone limiting production. Mr. Rowe has also obtained tungsten ore in considerable quantities for electric smelting. His first sale brought $16,000 per ton, and since then the works have been steadily producing under long-time contracts. I believe that to Mr. Rowe belongs the credit of first reducing the refractory silicate ores of manganese, iron and copper and producing commercial quantities of metal in the electric furnace using hydro-electric power.

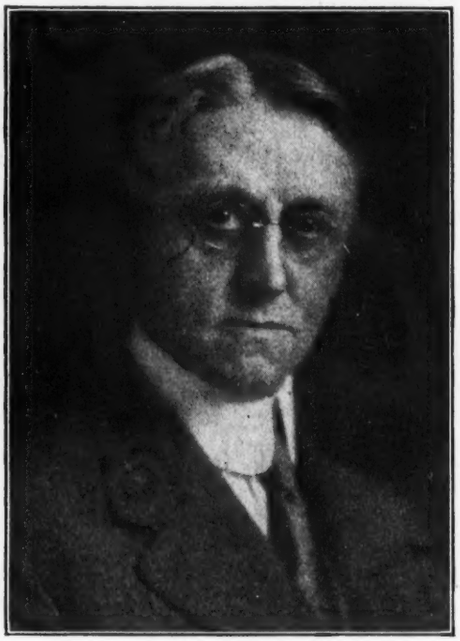
*180 Commonwealth Ave., Boston, Mass.

Distinguished American Metallurgists



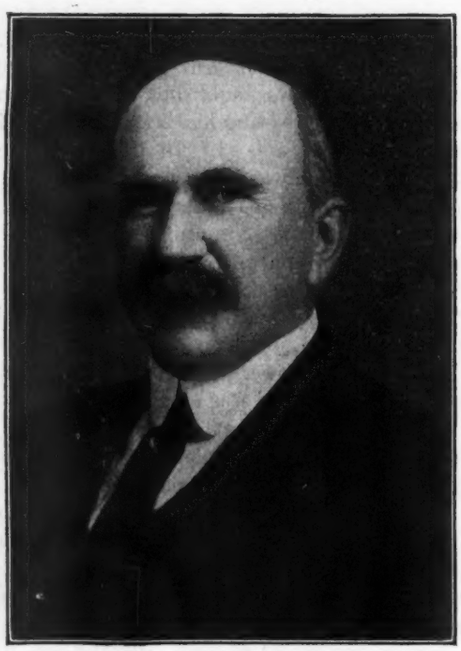
LOUIS D. RICKETTS

"Arizona's most distinguished citizen." Beloved by everybody. The great builder of smelting works. A metallurgist with imagination, who blazes new trails



DAVID H. BROWNE

If not the father of coal-dust firing he was distinctly the doctor who made the idea live and grow into a major improvement in the art of metallurgy, especially copper-smelting



EDWARD P. MATHEWSON

General manager of the Washoe works, who boldly showed what great economies could be effected in copper smelting in gigantic furnaces, both blast and reverberatory

FREDERICK LAIST

Metallurgical manager of the Anaconda. A leader in the development of Anaconda's new and marvelous metallurgy and pioneer in making electrolytic-zinc extraction a real art

Distinguished American Metallurgists

W. H. PEIRCE

Vice-president, Baltimore Copper Smelting and Rolling Co. One of the metallurgists who developed the art of basic copper converting—one of the major improvements in the metallurgy of copper

E. A. CAPPELEN-SMITH

Metallurgical director, Chile Copper Co. He collaborated with Peirce in developing basic copper converting and subsequently evolved the metallurgy of Chuquicamata in an original and brilliant way

ARTHUR S. DWIGHT

The dean of lead smelters. Famous also as a copper smelter. One of the inventors of the system of blast-roasting and sintering by which extraordinary savings have been effected in the treatment of lead and copper ores

RICHARD L. LLOYD

A keen and experienced copper smelter with original ideas, and an efficient manager. A co-inventor of the Dwight-Lloyd system of blast-roasting and sintering, which has proved important in many ways

The Smelting of Mercury Ores

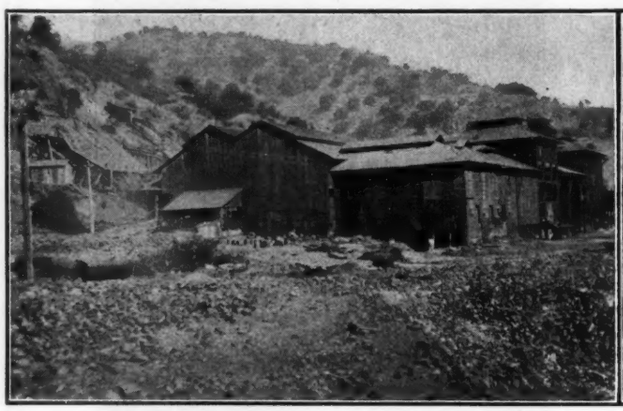
By W. H. Landers*

SYNOPSIS—Little improvement has been made in the metallurgy of mercury since the invention of the Scott tile furnace in 1876. The yield of the ores is diminishing, that for the last five years being less than 1%. New methods are being devised now and concentration, possibly flotation, is used to supply a rich product for smelting. A wet process is desirable to avoid the difficulties of smelting.

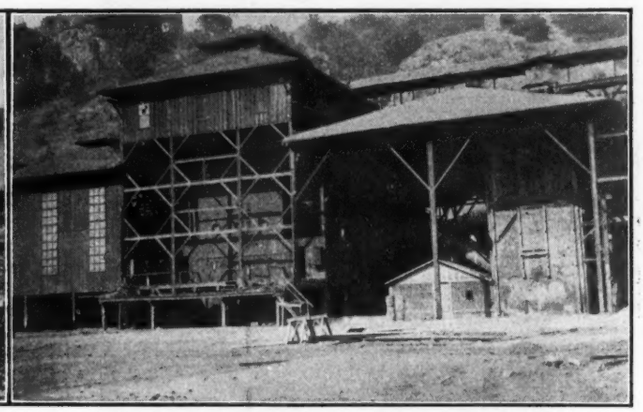
Of the many rare metals that the great war has brought into prominence, there is none more interesting than mercury. Being a necessary ingredient of detonators for small-arms ammunition as well as for torpedoes, floating mines, high-explosive shells and for the larger guns, where it is used in the form of fulminate of mercury, its price rose $37.50 per flask of 75 lb. net just prior to the opening of hostilities to $300 per flask in February, 1916. Like many others of the rarer metals, its market has been greatly abused by irresponsible speculators, and operators now realize that had the price been held down to lower figures, many users of the metal in this country would not have sought substitutes elsewhere or discontinued its use altogether. Habits of a business lifetime, however, are not easily broken, and the present price of $75 per flask is re-creating a normal demand and there is every prospect of a rise in the price in the near future. Stocks are low, and British quicksilver is selling at a much higher figure.

No new mines of any consequence were developed from the high prices, but many of the better-known producers seized the opportunity of rebuilding their somewhat dilapidated plants and have done extensive development work as well as added equipment such as furnaces and concentrating mills. It can safely be assumed that up to 1915 no improvements of any importance had been made in the method of extracting mercury from its ores since the development of the Scott tile furnace in 1871-76. The increased activity in this branch of the metallurgical industry has attracted some of the younger engineers, and the shortcomings of the old and recognized system are being brought out and corrections attempted.

Statistics indicate that for the last five years the yield from mercury ores in the United States (of which cinnabar is the only one of commercial importance) has been less than 1% of mercury per ton of ore. Ores running under 1% as recently as 1895 were not considered of sufficient value to mine. At New Almaden alone in the years 1869 to 1870 the mercury content of the ores ran as high as 5%, and it was during this period that the necessity of making use of the tierras, or fine ores running smaller than 1½ in. in size, caused the accomplishment of the Huttner-Scott furnace for fine-ore treatment. Prior to this time the richest ores were made into dobe bricks and burned in the regular shaft furnaces or kilns. Of the older methods of extracting mercury from cinnabar ores, many of which are still in use, there are retorts, intermittent furnaces and tile furnaces of various types. Up to 1915 no mention of mechanical furnaces can be found, nor was the successful commercial operation of any wet method of obtaining mercury attempted.



General plant at Hacienda



Scott furnaces at New Almaden

VIEWS OF TWO MERCURY SMELTING INSTALLATIONS IN CALIFORNIA

So far as is known, up to this period for a great many years, none of the operating companies has maintained assay offices or has made any attempt systematically to sample the ores going into its furnaces, the value of the ore being based on the yield in flasks from the number of tons smelted. This lack of adequate sampling may be attributed to the fact that the coarse ore (that is, ore running from the size of a man's fist up to pieces weighing several hundred pounds) has been charged directly into coarse-ore furnaces, and as these furnaces have been satisfactory in their operation, it has never been considered advisable to crush this coarser ore down to such a size that reliable samples could be taken. There has been, however, no excuse for the lack of sampling and assaying such ores as have been and are still being treated in the tile furnaces, and no doubt this is now being done to a more or less complete degree at all the mines. The advent of the younger engineers can be directly "blamed" for this, as the modern science of engineering, or really of operating any business, requires a knowledge of the losses sustained in its operations.

*Chief engineer, New Almaden Co., Ltd., New Almaden, Calif.

Assaying of mercury ores is most commonly done by the dry method, and while the chance for loss in this method is considerable, if carefully performed the results are found to check fairly well with those obtained by the volumetric methods. In this general discussion of the metallurgy of quicksilver it would take too much space to detail the various wet and dry methods of assaying mercury, as they can be found in some of the better-known chemical handbooks.

Lately the water concentration of cinnabar ores has been successfully developed in California, and the trend of the time seems to be to concentrate low-grade mercury ores before charging into the furnaces. As will be shown later on, the vapor losses from any of the furnaces are much less when treating high-grade ores than when running the lower grades, and the vapor is the one loss which it seems impossible to prevent by any means yet discovered.

The Field for a Wet Process

There is a decided field for a wet process for extracting mercury from concentrates or from the richer ores. Water concentration of cinabar has come to our attention as being used by the Manzanita Mine in Colusa County, California, where a small plant consisting of a Huntington mill and some bumping tables was installed several years ago, principally to try to save the gold that was in the ore. It was quickly noticed, however, that cinnabar was easily concentrated, but the commercial state of the industry was such that prior to its present revival money was not available for the purpose of experimentation along these lines. Many concentrators are in operation now in California, and more are being built. The Oceanic, Kings Consolidated, New Almaden, Cloverdale, Aetna and New Idria are all using them, varying from 50 to 300 tons per day capacity. As an adjunct to water concentration, many experiments have been made in the use of flotation, but so far as can be determined, none of the mines has actually installed working units, although it is expected that the New Almaden will have one in operation soon. Extractions as high as 86% have been obtained by crushing and tabling the ore, but there are undoubtedly some ores in which the cinnabar occurs in an almost amorphous state, where the extraction by tabling alone cannot be brought much above 60 to 70%. Careful tests have indicated that the losses here occur almost entirely in the fines that are apparently in suspension in the pulp; and as flotation results have shown that, so far as cinnabar is concerned, it can be successfully applied only to the fines, no doubt a total extraction of over 90% can in most cases be economically obtained. Other sulphides, notably pyrite, are almost always present in cinnabar ores, and this pyrite can be concentrated out with the cinnabar, proving a valuable addition to the succeeding furnace operation and cutting down the amount of fuel necessary to smelt the ore. Concentration has one other great advantage, which is that it eliminates the asphaltum products and other carbonaceous materials that are nearly always found in the ores and are among the chief sources of difficulty in the proper collection of the mercury after smelting. It might be well to mention here that all fire methods of reducing cinnabar call for subsequent condensation of the mercury vapors and that any hydrocarbon distillates that may be condensed with the vapors add greatly to the difficulty of collecting the metallic mercury.

Briefly, such concentrators as have been installed recently consist of rock crushers, ball mills and various types of tables. Jigs have been tried in one place and no doubt should be given a more general trial elsewhere. The coarser the concentrate that can be made, the more favorable it is for roasting in the furnace, and if retorts are excepted, none of the present furnaces would work very long on typical flotation concentrates.

The Methods of Mercury Reduction

In a more detailed discussion of the older methods of reduction that are still being used, that of the simplest as well as cheapest to install, namely, retorts, will be taken up first:

Retorts are made of cast iron, either of round or D-shaped cross-section, and have capacities varying from 50 to 300 lb. per charge. This very small capacity, together with the comparatively large amount of fuel necessary, has forbidden their use except at the very smallest mines and for the final treatment of mercurial soot from other furnaces. When improperly cared for, the losses in a retort plant are very large, but no doubt retorts will again be considered in the treatment of concentrates from wet concentrating mills. Intermittent furnaces other than retorts are seldom used and undoubtedly will disappear entirely, as too much time is lost in heating up and cooling off after the different charges.

Tile furnaces of the Scott type may be accepted as still the standard for cinnabar reduction, in spite of the fact that Mr. Scott has made practically no changes in their design since the original furnace was built at New Almaden in 1876. The weak points of the Scott furnace are: Their first cost; the great amount of brick used in their construction, with the resultant absorption of quicksilver; lack of control of the descending charges, with the occurrence of channels and rushes of ore; blocking of the tiles by wet ore and by clinkers, necessitating periodical shutdowns for cleaning out; plugging of the pigeonholes by ore dust and their consequent slagging near the fires; their inability to burn safely high-sulphide ores, due to the danger of the furnace getting afire from bottom to top, or as it might be expressed, lack of heat control; and also their inability to handle ores in which metallic mercury is present, as this mercury has been found to drop through from the top of the furnace to the ashpit without volatilizing, regardless of the temperature at which the furnace was operated. These furnaces have worked very well on freshly broken ore from the mines, but are found to give a great deal of trouble when highly oxidized materials such as old dumps and oxidized ores are charged into them.

Continuous furnaces of several types for coarse ore are in daily use and give complete satisfaction. They are all more or less on the lime-kiln order. The success of coarse-ore furnaces suggests the practicability of briquetting the finer ores or concentrates, and this no doubt will be attempted when a suitable binder is found. This binder must not in itself be a great heat absorber nor must it give off hydrocarbon vapors, which will afterward condense with the mercury in the condensing system. This naturally precludes the use of such materials as tar or asphaltum.

Up to the present writing, only two mechanical furnaces are known to be in operation, both 6-hearth Herreshoff roasters—one at New Almaden and one in Nevada about 35 mi. from Winnemucca. These were

erected last fall and can hardly be said to have passed the experimental stage. They are especially adapted to the burning of high-sulphur ores or for ores that contain some metallic mercury, which on this account cannot be roasted in any of the shaft furnaces. They have proved to be economical of fuel and can be erected for about half the cost of the regular tile furnace. They have the advantage of being able to control the temperature on each hearth and will find their greatest application in the smelting of large tonnages of cinnabar concentrates where the sulphur content is sufficiently high to reduce materially the amount of external fire necessary. Such concentrates cannot, by themselves, be roasted in any of the tile furnaces or course ore furnaces now in use. The problem here remains for someone to invent a continuous muffle furnace where the temperature can be controlled at any point to prevent fusion of high-sulphur ores.

The Fuel for Mercury Reduction

The best results in all types of furnaces have been secured through the burning of wood for fuel, but the cost of wood in some localities has made necessary the substitution of fuel oil. Wood requires less air for complete combustion, and the alkaline ashes, which to some extent are mixed with the gases leaving the furnace, are a decided advantage in the ultimate recovery of the quicksilver. Fuel oil, such as is used in California, needs a great amount of air for complete combustion and has the disadvantage of making a very greasy soot that is carried over into the condensers and greatly retards the collection of the mercury. To prevent this, it is necessary to have large fireboxes in which the combustion of the oil can take place, allowing only the hot gases to escape into the furnace; although in the case of the burning of coarse ore this feature is not so necessary, as the whole mass of the ore gets sufficiently heated to collect the soot and tarry products from the oil, preventing their escape with the gases. The action in this case is similar to that of the gas producer in which fuel oil is sprayed against a checkerwork of brick.

The drying of ores prior to their introduction into the furnace, while increasing the capacity of the furnace and having a tendency to minimize hangups, is not in general use in California, most operators preferring the simpler method of charging their ore directly into the top of the furnace and letting it dry out there. At first thought it would appear as though the proper procedure would be to convert the first condenser into a drier and have the raw ore serve the double purpose of cooling the gases and drying the ore; but as the first condenser generally collects a considerable amount of ore dust and as it is a difficult matter to separate this dust from the condensed quicksilver, this plan has been abandoned.

Before discussing the various types of condensers in use, it will be well to consider the composition of the ore. This varies considerably according to the locality from which it is mined, but as a rule, outside of a small percentage of cinnabar usually present, there are large quantities of calcite and dolomite and often quartz. Asphaltum and carbonaceous material is frequently present and in most instances varying quantities of iron pyrite. At New Almaden it has been found that a cubic foot of raw ore weighing 102 lb. when charged into the furnace, weighs only 70 lb. after roasting. It will be seen at once that the gases coming from the furnace and out of which the mercury has to be condensed will consist in a large measure of H_2O, CO_2, SO_2, SO_3 and CO in addition to the usual products of combustion.

Tars, pitches and other volatile hydrocarbons are mixed with the gases, some of which afterward condense with the water and mercury. In order to secure the decomposition of the cinnabar, it is necessary to subject it to a temperature in excess of 670° F. This temperature must be maintained in the gases coming out of the furnace for a sufficient length of time to permit the elimination of ore dust, and then must be cooled as rapidly as possible to force the condensation of the mercury. As this condensation takes place in the form of a mercurial dew, the velocity of the gases must be as low as possible consistent with maintaining the furnace draft and enough space provided for this fog to settle out of the gas passing through the condensers. The possibility of great loss is here apparent, owing to the fact that the entire volume of gas leaving the furnace must be saturated with mercury vapor at the temperature of exit and will continue to be so saturated until after it is finally delivered into the atmosphere.

The present problem is to reduce this gas volume in the furnace as much as possible and to have the gases leaving the condenser system as cool as is commercially possible. As the necessary draft cannot be secured under these conditions without having the final temperature too high and the resulting vapor loss too great, some mechanical means is necessary to maintain the movement of vapors through the condensers. Low-speed fans have been found best suited for this purpose. As this discussion is not intended to enter into such technical subjects as vapor densities, specific heats, vapor tension, etc., the products of the condensers will next be mentioned.

Products of the Condensers

In the first condenser after the furnace, the product is largely dry-ore dust and little mercury; the next condensers will show varying amounts of condensed water and mercury, this water carrying considerable oil and other hydrocarbons of a tarry nature, as well as sulphuric acid. Varying amounts of what is called mercurial soot are present in all these condensers, and it is the separation of the metallic mercury from this soot that offers the greatest difficulty in securing an adequate clean-up. Present practice is to mix this soot with wood ashes or lime and, after drying, to work the mercury out of it by manual or mechanical means. The ashes containing wood lye or the lime have a tendency to brighten the mercury and give the minute globules a chance to run together.

No matter how this soot is worked over, a large proportion of the mercury still remains entrapped in it in the form of microscopic globules, and it is customary in the larger plants to charge this residue back into the furnace. Some plants, however, retort this soot and in this way get out practically all the mercury, but such a retorting process is long, tedious and subject to considerable opportunity for loss. Up to the present no other means has been devised for separating the mercury from this soot.

Condensers are usually built of brick, stone, cast iron, glass or wood. Lately concrete and hollow tile have been

used successfully. The cooling of the gases in these condensers is often assisted by the introduction of what are known as water-backs, or coils of pipe either of iron or terra cotta, through which cold water or air is circulated. Air flues either of iron or terra cotta pipe are also used, mainly for cooling the gases in the first condensers, and water sprays have been introduced for the same purpose, although open to the objection of carrying away floured mercury, which is very difficult to save.

All condensers constructed of brick, stone or concrete have the serious defect of absorbing great amounts of mercury, largely from the vapors that permeate into the walls, and their necessary thickness greatly decreases their efficiency as coolers.

Wooden condensers, either vertical or horizontal, are now being used to a considerable extent and have been found satisfactory where the temperature of the gases permits their use at all. They are less subject to attack by acid waters than either masonry or cast iron, and have the added advantage of low first cost. Ironwork of any description lasts very well in the construction of condensers where the temperature does not fall below the boiling point of water, but are rapidly attacked at lower temperature.

Glass and wood condensers were formerly quite extensively used at New Almaden, but were abandoned on account of their rapid deterioration during shutdowns of the furnace. Various plasters or cements supposed to be acid-resisting have been tried on the walls of condensers with the idea of rendering them less porous and less subject to attack by acids, but as yet have not proved entirely satisfactory for these purposes.

Principal Forms of Mercury Losses

In roasting mercury ores losses occur principally in the following forms: Cinnabar or metallic mercury remaining in the furnace residue. This can be taken as low and should be almost negligible with good furnace work.

Absorption of mercury by the brickwork of the furnaces and condensers previously referred to. This is a loss that cannot be very well estimated, and while it may not be considered as an ultimate loss, it remains a practical one as long as the plant is in operation. In one instance the tearing down of a furnace and condenser system to my knowledge produced over 1,000 flasks.

Air leaks in the plant will cause loss or not, according as to whether care is taken to always have an in draft. Stack, or exit, losses are easily the most serious of all, as before mentioned. The large volume of gas coming out of the final condenser is saturated with mercury at the temperature of escape, and no means has yet been devised for preventing this loss. In terms of the mercury recovered, assuming that only twice as much air went into the furnace as was necessary for theoretical combustion, this loss has been measured to be as large as 2% of the mercury recovered when treating a 1½% ore, and with an exit temperature as low as that of the outside atmosphere. Double that amount has been shown on an ore of 0.7% mercury. As most of the quicksilver furnaces in California are treating ore of less than ½ of 1% mercury, it can readily be understood that the loss under the conditions cited might reach as high as 5% of the recovered mercury when the excess air is kept down to double the theoretical quantity. It is seldom found by measurement that double theoretical air can be maintained, and it is more likely that at least four or five times as much air as is necessary for combustion finds it way into the system. This loss then may reach as high as 10% of the mercury in the ore and may be considered as a fixed loss. In addition to this vapor loss there is the mercurial mist, or fog, which is present in the gases leaving the condensers. This has been estimated to amount to several times the fixed-vapor loss, dependent on the number of condensers used and the velocity of the gases through the system.

Another source of loss is that in floured mercury in the water leaving the condensers. It has not been possible to measure this, but it is known to be considerable. Washing of condensers in cleaning-up operations undoubtedly has caused great loss in this respect.

The Absence of Careful Sampling

In summing up the losses in the treatment of mercurial ores by the apparatus now in general use, it is to be regretted that careful sampling of the ores over long periods of time has not been commonly done. At at least three plants with which I am more or less familiar, sampling has been done at stated times with the object of discovering what this loss is, and in no case was it shown to be less than 20%, and that on a comparatively high-grade ore. In all probability the losses in fine-ore furnaces exceed 25% and may even reach as high as 40% on extremely low-grade ores and with too much air. Coarse-ore furnaces, on account of the small amount of draft necessary do not incur so great a loss when proper attention is paid to control of the air admitted into the furnace, and the smallest losses of all should be met in properly operated retorts or muffle furnaces.

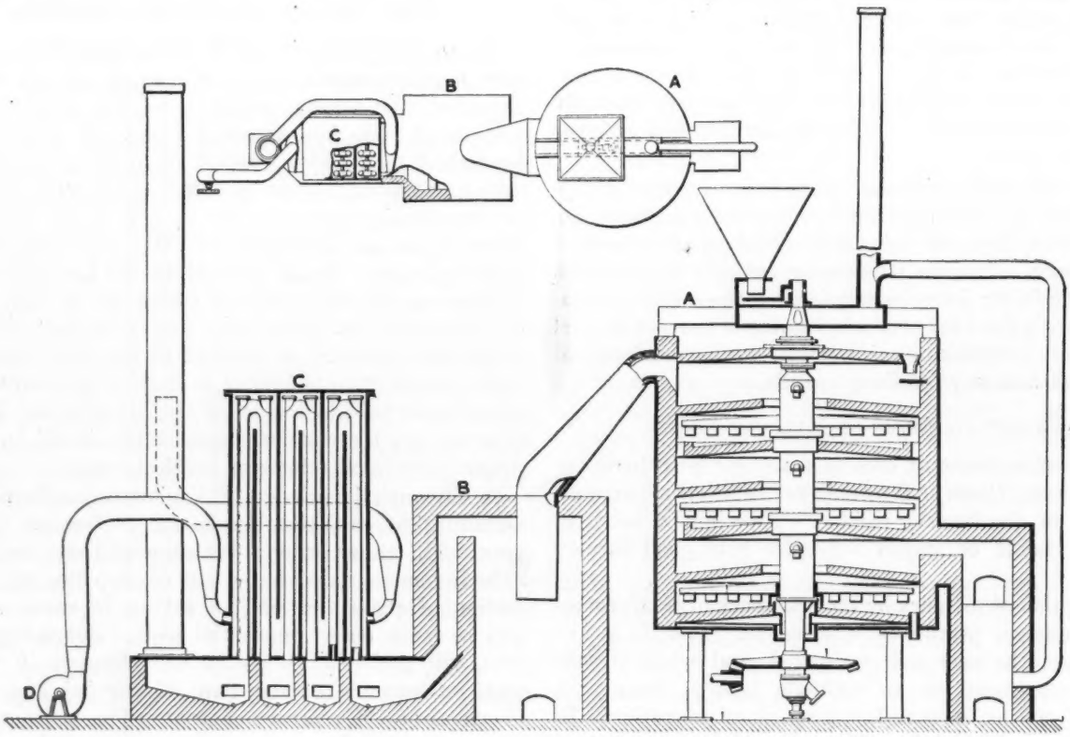
A thorough knowledge of the losses, mechanical and metallurgical conditions leads one to forecast that the future will either bring out a successful wet method for reducing mercurial ores or will develop the yet concentration of these ores until a saving in excess of 90% will be made on a commercial scale. Furnacing of the ores will probably always be the cheapest in per ton costs on tonnages greater than 25 per day and on ores in excess of 1% mercury content. The losses sustained in treating low-grade ores in furnaces will in all probability be greater than that of wet concentration plus a proper retorting of the concentrates.

Mines having large investments in furnace plants will continue to use them up to capacity, but will build concentrating plants for their lowest-grade ores, mixing the resulting concentrates with the ore going to the furnace. The low per-ton cost of a concentrating plant together with its necessary retorts will probably preclude the erection of more large furnaces, although in the case of the installation of a large concentrator the quantity of concentrates obtained will necessitate the construction of some type of furnace with greater capacity than can be secured from retorts. This will bring in mechanical furnaces having little or no application of external heat, the concentrates containing sufficient sulphur to provide their own fuel. Such a condition would be ideal for the distillation of mercury, as the volume of furnace gases with attendant vapor loss could be kept down to a minimum. The price of mercury may influence the choice of process.

Landers Mercury Furnace

A new quicksilver-distilling apparatus comprising a roasting furnace, a dust settler with the gas outlet communicating with the furnace, a condenser communicating with the dust settler, a stack to which the uncondensed gases from the condenser are delivered, and means for subjecting the condenser to a cooling medium, together with means for conducting the cooling medium, with its absorbed heat, into the stack to increase the draft through the apparatus, has been designed by William H. Landers, of New Almaden, Calif., to whom U. S. Pat. No. 1,195,-236 has been granted. The features of the furnace are shown in the accompanying drawings.

In the accompanying illustration a vertical sectional elevation of the apparatus, and a plan of it are shown. The furnace is shown at *A*, and may be of any suitable type adapted for the distillation of quicksilver from its ore. The best form is considered to be that known as the multiple-hearth furnace and is thus illustrated here. The dust settler is shown at *B* and the condenser at *C*, the fan that supplies the cooling medium for the condenser being shown at *D*.



PLAN AND SECTIONAL VIEWS OF THE NEW LANDERS MERCURY-SMELTING FURNACE

Circulating air is admitted and passes through and cools the shaft and arms of the furnace and is discharged into the stack, from which it may be diverted through the return pipe, in a heated condition, to the furnace grate for the combustion of fuel and the oxidation of the ore, the furnace grate communicating through a flue with the lower roasting hearth of the furnace. The air and products of combustion pass through the flue into the furnace and over the hearth in a direction opposite to the flow of ore, going to the vapor and gas outlets.

The settler is made of brick or concrete or any material that will sufficiently conserve the heat, and for a similar purpose, the vapor- and gas-outlet flue from the furnace is best covered with heat-insulating material. The dust settler has two objects: First, to keep the vapors and gases sufficiently hot to prevent any precipitation or condensation of the quicksilver in the settler; second, by its large dimensions compared to the inlet, to reduce the velocity of the vapors and gases, allowing the dust to separate and settle more effectively.

The condenser comprises a number of collecting chambers, or trays, in a base, successively connected by a number of standpipes, the last chamber communicating with the stack. Between and around the standpipe are baffles which form the space for the circulating cooling medium. This medium is supplied by the fan, which connects by a pipe with the baffle space, and this space communicates at the outlet end of the complete path of circulation with a pipe that is carried to and enters the stack. The air serves the double purpose of a cooling medium for the condenser and, in its heated condition, due to the interchange of heat in the performance of its first function, it serves the further purpose of increasing the draft and creates a suction in the entire system, inducing a current of vapors and gases away from the furnace, thus taking them away from the roasting ore.

The ore in crushed condition, say from ¾-in. mesh down, is roasted in the multiple-hearth furnace. The gases are then driven off, together with dust from the furnace, passing over into the dust settler. Here the gases will remain hot enough to prevent precipitation of quicksilver, but the current will be slow enough to provide for the settling of all the dust. The gases then pass into and through the condenser, and the quicksilver settles in the collecting boxes. The condensation is due to the current of air from the fan passing through the baffle spaces of the condenser. This quickly cools the pipe and the gas, when liberated, is still heated and is discharged into the stack, thereby increasing the draft and creating effective suction throughout the apparatus.

Changes in Smelting Practice of Anaconda Copper Mining Co.

By Frederick Laist*

SYNOPSIS—Recent changes in smelting practice of the Anaconda Copper Mining Co. have materially improved the results obtained. Pulverized coal is largely used in the reverberatory furnaces, greatly increasing the charge smelted per ton of coal. Great Falls type converters have replaced the old barrel-shaped ones. Cottrell fume-treatment system has been installed. The changes were made necessary by the increased tonnages required to be smelted.

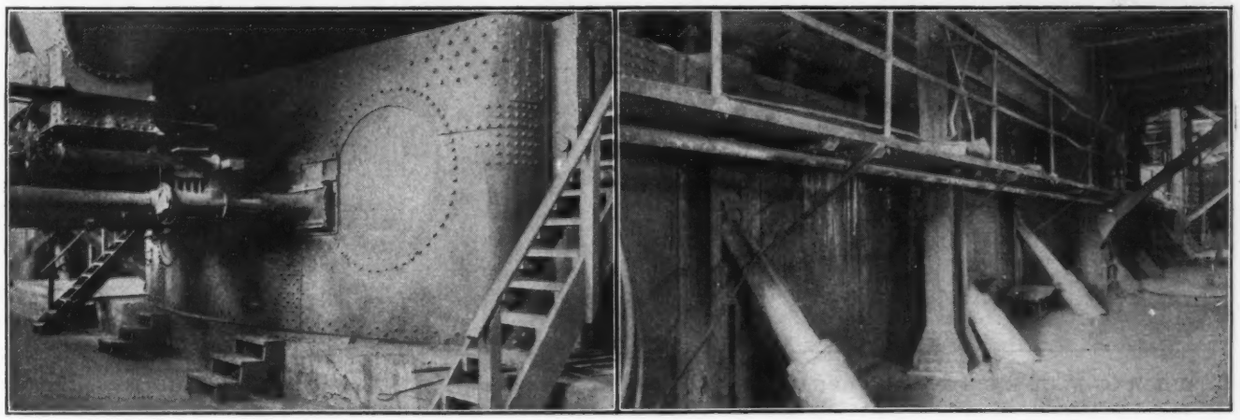
An extensive program of reconstruction and new construction at its plants in Anaconda and Great Falls was decided upon by the Anaconda Copper Mining Co. in December, 1914. Considerable experimental work had been done prior to this date and had demonstrated that the recovery of copper from the Butte ores could be greatly increased by the use of the flotation process of concentration. The high recovery possible by this process made it seem desirable to concentrate all the ore instead of sending part of it to the blast furnaces. It was also felt that concentrating operations had best be confined to Anaconda in order to avoid transportation charges on ores that had hitherto been sent to Great Falls. This made it necessary to increase the concentrating capacity at Anaconda and this, together with the treatment by concentration of ore that formerly had been smelted direct, together with the increased concentrate production resulting from the higher saving, caused a tremendous increase in the amount of material requiring treatment in the reverberatory-smelting departments.

Prior to this time one furnace in the reverberatory plant had been equipped with coal-pulverizing machinery and burners. The results of this experiment had been so satisfactory that it was decided to equip the entire plant in the same way. This, we knew, would result in a largely increased capacity, and in order to provide the additional capacity needed it was decided to enlarge the furnaces from 19x125 ft., to 25x143 ft. The converter plant at Anaconda was in a decidedly run-down condition and consisted of 13 barrel-shaped converters. It was decided to replace these with seven 20-ft. upright converters of the Great Falls type. The increased reverberatory-smelting capacity, of course, necessitated additional roasters, and it was decided to construct a new roasting plant containing twenty-eight 25-ft. furnaces.

With regard to Great Falls, it was determined to adopt reverberatory smelting exclusively for that plant and to supply it with concentrates to be shipped from Anaconda. The coal burned at Great Falls is of rather poor quality, and gas-fired furnaces had been used up to that time. A furnace had been constructed with a large firebox which worked somewhat on the gas-producer principle. This was not very successful, and it was decided, after making preliminary tests at Anaconda, to adopt coal-dust firing at Great Falls also.

This entire program has now been completed, and the results obtained from the changes have fully met our expectations. The concentrator is treating 15,000 tons of ore per day and is making a recovery of 96.5%. All the jig and table concentrates are collected in bins, from which they are distributed by means of trains operated by air locomotives, part of the concentrates going to the No. 1 roaster plant (which is the old plant, consisting of sixty-four 16-ft. MacDougall furnaces), part being shipped to Great Falls and part going to the new No. 2 roaster plant. All the flotation concentrates are collected in a centrally located Oliver-filter plant and conveyed by means of belts directly into the hoppers feeding the furnaces in the No. 2 roaster plant.

The quantity of flotation concentrates going into this plant averages 1,700 tons per day, with which is mixed about 500 tons of concentrates from the bins and about 200 tons of fine limerock. This amount of material is being treated at the present time in 24 furnaces, as four of the 28 furnaces are being used for roasting zinc concentrates. On account of so large a proportion of the charge being excessively fine, these furnaces were designed with a view to producing a minimum of dust and are



THE REVERBERATORY FURNACES AT GREAT FALLS, MONT.

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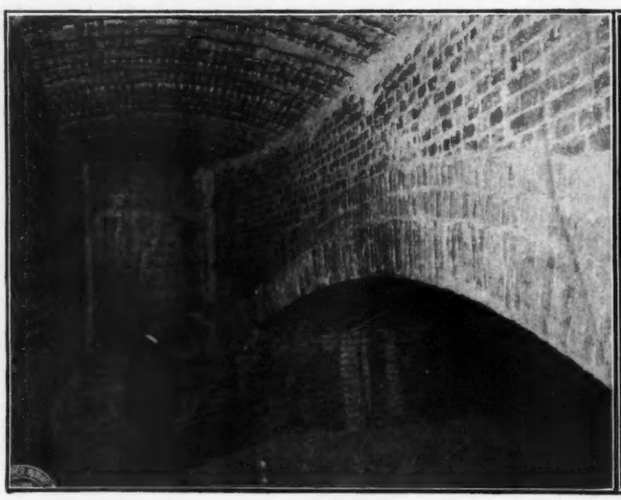
operated with a minimum of draft. It was realized, however, that in spite of anything we could do, we would probably have considerable dust to contend with, and therefore, in addition to equipping the plant with a dust chamber and flue of ample proportions, a Cottrell treater, capable of handling 400,000 cu.ft. of hot gas per minute was installed. This treater is not in operation at the time of this writing, but will probably be running early in September. The course of the gases through the treater is vertical, but instead of being filled with pipes, the inside of the treater is divided into rectangular spaces by means of plates of corrugated iron. The plates are 12 in. apart. Chains are hung at intervals of about 6 in. midway between the plates and form the positive electrodes. The treater is referred to as being of the "box type" and is considerably less expensive per unit of capacity than the "pipe type" of treater.

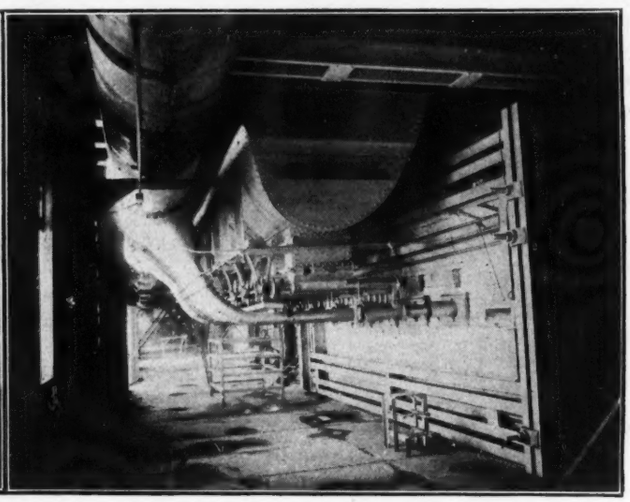
The furnaces in the No. 2 roaster plant contain as a principal distinguishing feature, the large brick shaft, originally introduced and patented by Utley Wedge. This shaft is 5 ft. in diameter and contains in its interior all the pipe connections and the fastenings by which the arms are held in place. This feature is undoubtedly valuable in that repairs to the water system or the arms can be made without cooling off the furnace, which is a rather serious matter with furnaces of so large a size. The furnaces are water-cooled, as air cooling has proved itself inapplicable to concentrates containing as much iron pyrite as those made from Butte ores. The center shaft runs on a button bearing. This has been designed and installed to take the place of a roller bearing with which the furnaces were first equipped and which gave considerable trouble. Each furnace is driven independently by a 15-hp. totally inclosed motor, drawing its cooling air from outside the building. A train of gears running in oil in a tight gear case transmits the power to a large pinion which meshes with a crown gear near the lower end of the shaft. The calcine hoppers are partitioned off from the rest of the building, so that the dust and gases evolved in loading the trains are confined. The loading chambers extend the length of the building and are about 25 ft. wide. They are connected with a 12-ft. brick stack, so that a current of air keeps the dust and gases moving always in one direction and away from the men loading the cars. It was our intention to equip this stack with a treater for catching dust that might escape, but measurements have shown that the quantity of dust getting out is too small to make it worth while.

Reverberatory Furnaces Fired with Coal Dust

The reverberatory plant takes the calcine from both No. 1 and No. 2 roaster plants, as well as flue dust from all the various dust chambers. It consists of eight reverberatory furnaces of the dimensions already given. These furnaces use pulverized coal from the Diamondville mines of the Anaconda Copper Mining Co. and are capable of smelting as much as 650 tons of charge per 24 hr. The fuel ratio for a period of six months has averaged 6.8; that is, we smelt 6.8 tons of charge with one ton of coal. The furnaces operate continuously, and slag runs in a steady stream from a hole in the front end. The matte is also tapped at the front of the furnace. The latter change was made necessary by the use of the side-charging system. Contrary to former practice, these furnaces contain only an inconsiderable bath of matte, although of course they contain quite a large body of molten slag. The remodeling of the reverberatory plant has more than fulfilled expectations, and besides giving us almost 2½ times the former capacity in the same building and with the same number of furnaces, has greatly decreased our reverberatory-smelting costs.



INTERIOR OF FLUE END OF REVERBERATORY FURNACE

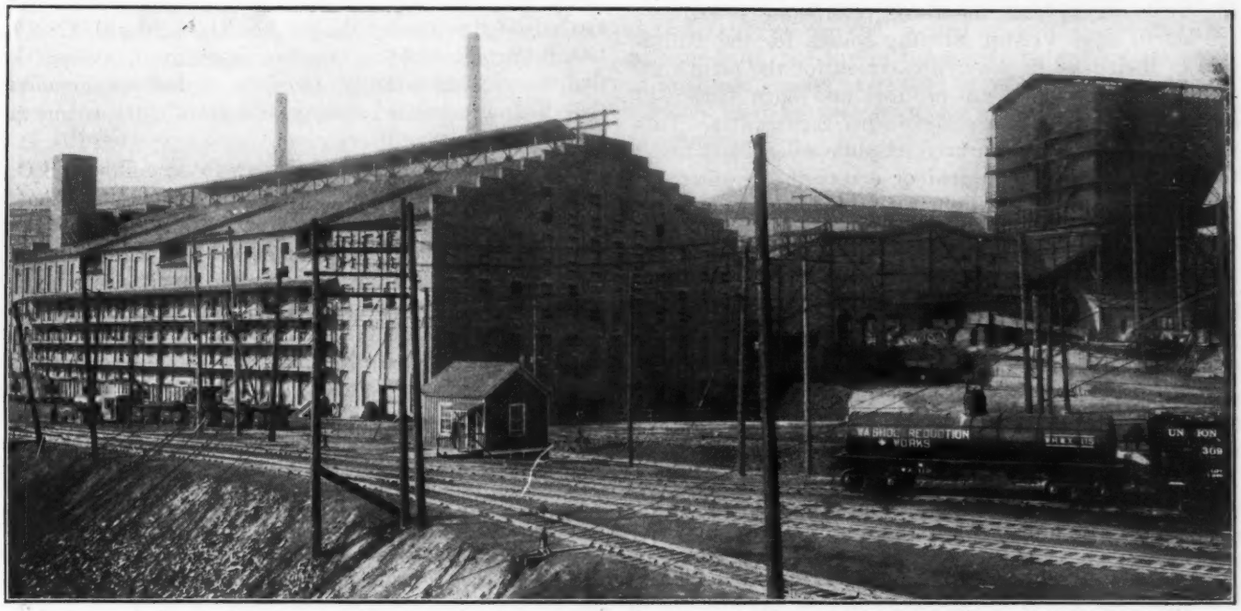


COAL-DUST BURNERS OF REVERBERATOY FURNACE

The results obtained at Great Falls have been equally gratifying. At this plant the furnaces are somewhat smaller—20x125 ft. The coal used contains 23% of ash, and when burned in the gas-producing firebox with which one of these furnaces was formerly equipped, smelted only 225 tons of charge per day with a fuel ratio of about 2.25. The same coal used in the pulverized form now smelts nearly 500 tons of charge with a ratio of 4.8 tons of charge per ton of coal.

Owing to the abnormal demand for copper and the high price obtained, the blast-furnace plant at Anaconda is still operating at maximum capacity. This, however, is only temporary, and the plant will be closed with the exception of one small furnace to be used for smelting coarse and high-grade material, such as a small amount of exceptionally high-grade ore, matte and slag cleanings and barrings from the roasting furnaces.

In order to take care of the converter slag under these new conditions, a reverberatory furnace, 25x150 ft., was constructed in a portion of the converter building that had formerly been used as the lining department when the siliceous linings were still being used in the converters. This furnace, also, is heated with coal dust and is provided with three spouts for introducing the molten slag. The furnace is completed, but has not yet been put into regular operation for the reason that as long as the blast-furnace plant continues in operation the converter slag is needed there as a flux. It is intended to operate this furnace on a siliceous charge high in sulphur so as to provide the silica necessary to combine with the excess iron in the converter slag and thus produce a furnace slag running about 37% SiO_2. At the same time a rather low-grade matte will be made, which can be tapped into ladles and poured back into the converters. The slag will run out at the front of the furnace in a continuous stream into a jet of water, which will granulate it and convey it down a launder to the slag dump.



GENERAL VIEW OF NO. 2 ROASTER PLANT, SHOWING FLUE AND COTTRELL TREATER

Arrangement Providing for Slag Disposal

In this connection it might be interesting to note that within the past year the space originally provided for the dumping of slag has been practically filled up. At the time the Washoe Reduction Works were built, it seemed as though the dumping ground for slag was practically inexhaustible, and up to about six months ago the disposal of slag required little attention beyond granulating it and flushing it down launders by means of water. After investigating various methods of disposal, it was decided to allow the slag to accumulate in small ponds at the ends of the launders. From these ponds it is excavated by means of a large electrically operated locomotive crane and loaded into dump cars holding about 30 tons each. The cars are operated in a train of six, by means of an electric locomotive. They are equipped with compressed-air cylinders for dumping, and the whole train can be dumped at once by the engineer on the locomotive. This method of handling has proved to be effective and cheap. Instead of sloping downward from the ends of the slag launders, the new dump now slopes upward with a 2% grade and it is estimated that dumping room for a period of at least 30 years has been provided.

The large amount of extremely fine flotation concentrates that has to be handled has given rise to no serious smelting problems. As far as we can see, the dust losses from the reverberatories are inconsiderable. The most serious difficulty at first seemed to be the handling of the calcines from the roasting plant into the reverberatory furnaces. The calcine produced from flotation concentrates is not only inconceivably fine, but on account of the gases contained therein, is possessed of almost the properties of a fluid. It runs out through the smallest cracks and holes, and its angle of repose is practically zero. The reverberatory furnaces are equipped with trough-shaped hoppers about 60 ft. long. Calcine dumped at one end of these hoppers will flow to the other end, the surface being almost horizontal. Of course clouds of dust are evolved whenever a car is loaded from a calcine hopper or whenever the calcine is dumped from the car into the reverberatory hopper. We directed considerable effort toward the construction of some sort of arrangement by which a tight joint could be made between the car and the hopper. Our efforts in this direction, however, have proved fruitless. It seems almost impossible to construct a device sufficiently tight and at the same time sufficiently quick-acting to answer our requirements. It is, moreover, necessary to provide some sort of vent on the cars for allowing the escape of the gas and air contained in the car. Screens for this purpose are useless as no screen seems to be fine enough to hold back the dust. We tried asbestos cloth, but this did not allow the gases to escape with sufficient rapidity.

We finally came to the conclusion that the best method of overcoming the difficulty was to load or unload in a sealed-off chamber or tunnel which is connected at one end to a stack or fan so as to create a draft away from the workmen. The men are thus out of the dust, and the dust is, moreover, discharged at a point where it can be

re-collected if its amount is sufficient to make it worth while. We find, however, that the quantity of dust actually lost is a very small percentage of the whole, although to see a car loaded one would think that the loss must be serious indeed. One of our reverberatory furnaces is being equipped with unloading tunnels just large enough in cross-section to admit the calcine cars, only about 6 in. of clearance being provided. A comparatively small volume of air will thus suffice to keep the dust moving toward the far end of the tunnel. Doors are provided at frequent intervals along the sides, so that ready access can be had to any car in the train.

Steam Power from Waste Gases*

At the Arizona Copper Co.'s smeltery at Clifton, Ariz., the waste gases from the three reverberatory furnaces are led to seven 712-hp. Stirling boilers for the utilization of their heat in power production for the plant.

The reverberatories are oil-fired and burn from 240 to 365 bbl. of California crude oil per furnace day. This variation covers a one-furnace schedule when hand firing for high tonnage is required or covers the requirement for two furnaces under light firing and correspondingly low tonnages smelted.

The gases leave the furnaces at temperatures of from 1,800 to 2,000° F. and, after passage through the steam boiler plant, exit at temperatures ranging from 471° to 588° F., depending on the number of reverberatories fired and the number of boilers in service. The gases from one furnace are passed through five boilers, but when two furnaces are in commission, six or seven boilers are used.

When smelting in one furnace, three direct-fired boilers are in continuous service to supply the power requirements, but the night load is light, therefore the boiler efficiency is low. The pounds of water evaporated per pound of oil averaged 11.98 over a period of eight months. The oil averages around 15° Bé. and 18,200 B.t.u.

With two furnaces in operation, there is sufficient waste heat to generate all steam requirements for the night load, but oil must be used to carry the day load. Under these conditions, rather than keep the oil-fired boilers under steam over night, the three oil-fired boilers are not used. Instead, oil is burned under the waste-heat boilers. The oil so burned is measured and credited with evaporating 11.98 lb. of water, in the same manner as under oil-fired boilers on a one-furnace basis.

All boilers contain Foster superheaters, and deliver steam to the mains at 175 lb. pressure. The temperature of steam delivered at the power house is about 475° F. The net steam delivered to the power-house engines is credited to the boiler plant. Steam used in heating and atomizing oil and for other miscellaneous purposes, as well as steam wasted, is absorbed in the furnace-oil costs.

Under one-furnace conditions, the waste-heat boilers averaged over a period of eight months, 7.71 lb. of water evaporated per pound of oil burned in the furnace.

The furnace-boiler division receives credit from the power house varying from 36 to 56% of the oil burned in the smelting furnace.

The indicated horsepower from the waste-heat boilers per ton of solid charge smelted on a one-furnace basis over a period of nine months averaged 98.71 i.hp.-hr., whereas on a two-furnace basis over a period of seven months the average was 114.34 i.hp.-hr. from waste heat only.

Reverberatory dust caught in all the boilers does not exceed 5 tons monthly when running one reverberatory. The net steam delivered to the engines is credited to the boiler plant. Steam used for heating, atomizing oil and for other purposes is absorbed in furnace-oil costs.

Furnace gases leaving the waste-heat boilers at temperatures varying between 471° and 588° F., are conducted through 6-ft. diameter steel pipes into a flue connecting with the main chimney. The temperature of gases in the flue ranges between 400° and 500° F. at different points, and at these temperatures the average velocity of gases is 10 ft. per second when running one furnace. An average analysis of this gas is SO_2, 0.3%; CO_2, 5.9%; O, 1.92%; CO, 0.4%; N, 80.5%; SO_3, not determined. When the flue was cleaned recently, 100 tons of dust was removed that had accumulated during two years' furnace operations.

The composition of this dust was as follows: S_2O_2, 17.4%; Al_2O_3, 6.3%; total Fe, 11.8%; CaO, 2.3%; S, 10.3%; Cu, 9.65%; free H_2SO_4, 3%; H_2O, 9.5%.

The flue roof, originally made of No. 14 steel plate, was so pitted and eaten through that repairs were necessary after eight months' service. Concrete slabs reinforced with wire netting were laid on top of the steel plate and all joints filled with asphalt.

The following table shows the amounts of power absorbed in the various operations of each department:

AMOUNTS OF POWER ABSORBED IN EACH OPERATION

Divisions	Kilowatt-Hours One Furnace	Kilowatt-Hours Two Furnaces	Kilowatt-Hours per Ton New Material One Furnace	Kilowatt-Hours per Ton New Material Two Furnaces
Sampling:				
Receiving, h.p. air converted to kw.-hr.	1,813	2,590	0.10	0.11
Crushing, electric	10,501	21,548	0.59	0.95
Sampling, electric	1,146	2,351	0.06	0.10
Bedding, electric	3,819	7,836	0.22	0.34
Reclaiming, electric	22,576	22,843	1.28	1.00
Total	39,855	57,168	2.25	2.50
Roasting:				
Roaster furnaces, electric	7,692	7,495	0.43	0.33
Calcine cars, electric	3,140	5,093	0.18	0.22
Total	10,832	12,588	0.61	0.55
Reverberatories:				
Reverb. furnaces, electric	3,013	3,303	0.17	0.14
Reverb. furnaces, h.p. air converted to kw.-hr.	453	647	0.03	0.13
Reverb. furnaces, l.p. air converted to kw.-hr.	37,339	72,774	2.11	3.19
Slag railway, electric	4,420	10,451	0.25	0.46
Boilers, h.p. air converted to kw.-hr.	1,813	2,590	0.10	0.11
Boiler feed-water pumps, electric	31,220	20,553	1.77	0.90
Oil pumps, electric	4,030	2,009	0.23	0.09
Total	82,288	112,327	4.66	4.92
Converting:				
Converters, electric	5,263	5,674	0.30	0.25
Converters, l.p. air converted to kw.-hr.	218,235	206,802	12.34	9.07
Cranes, electric	22,790	19,635	1.29	0.86
Bullion casting machines, electric	2,340	2,920	0.13	0.13
Total	248,628	235,031	14.06	10.31
General Works:				
River well, electric	6,760	8,001	0.38	0.35
Boiler and machine shops, electric	2,900	2,730	0.16	0.12
Boiler and machine shops, h.p. air converted to kw.-hr.	4,986	7,122	0.28	0.31
Yards, electric	1,313	1,439	0.07	0.06
Laboratory, electric	2,807	3,077	0.16	0.13
Total	18,766	22,369	1.05	0.97
Total, all divisions	400,369	439,483	22.63	19.25
Dry tons new material treated	17,687	22,793		

*Excerpt from "Smelting at Arizona Copper Co.'s Works," a paper presented at the Arizona meeting of the A. I. M. E., September, 1916, by F. N. Flynn, superintendent of the smelting department, Arizona Copper Co., Clifton, Ariz.

Tuyere Connections for Copper and Lead Blast Furnaces

By Richard H. Vail

SYNOPSIS—A presentation of the leading types of tuyere connections used at the North American smelting works, together with brief comments on the designs by the plant managers or superintendents.

Tuyere connections used at important North American smelting plants are illustrated on the succeeding two pages. While tuyere service at the various plants is practically identical in its general aspects of supplying air to the blast furnace and removing locally trapped slag, yet there are numerous refinements that may improve the practice—depending on the local conditions at different works. An examination of the accompanying drawings will show that nearly every smelting plant has made some improvement, these improvements varying with the predominant condition that was to be remedied at the individual plant.

Summarizing generally and briefly, it will be noted that at Anaconda, where slagging is comparatively infrequent and large tonnages predominate, a special effort has been directed toward the saving of power expense by reducing air leakage; Copper Queen and Boston & Montana have tried multiple-tuyere boxes, presumably with the intention of reducing construction cost; Detroit's tuyere box—of more recent design than most of the others—presents some refinement especially in the matter of the cover, which is easily removable when the tuyere has slaggd; the Traylor tuyere represents an eclectic equipment embodying the wide experience of its makers, incorporating ball-and-socket joints to expedite repairs, slag-drainage and air-conserving features, as well as an automatic safety valve for the lead-furnace tuyere connection; the automatic cutoff is also a feature of the Eilers tuyere box long in use at a number of the American Smelting and Refining Co.'s plants; the Midvale tuyere box provides against air leakage by using adjustable capscrews to hold the tuyere cap close to the face of the tuyere box, and also represents other improvements over the original design used by the United States Smelting Co.

Comments on the Tuyere Designs by the Works Managers

Some brief comments on the designs used at the various plants have been made by the managers or superintendents, who point out the particular features that have been developed to meet the predominant necessity at each plant. Commenting on the Anaconda tuyere connection, E. P. Mathewson says:

"An advantage of the Anaconda style of tuyere connection is the extremely short space between the downcomer and the jacket. Where the bustle pipe will admit of it, this space can be made still shorter; the shorter it is the better. Another feature is the tuyere-box cap with the peephole and plug to close same. This gives a very tight joint, so that air leaks about the tuyere box are practically unknown. Leaky tuyere pipes and boxes are a source of great waste about a smelting plant. This is little appreciated by the furnaceman or the blast-furnace foreman, and it is up to the superintendent to see that all these fittings are tight."

The Copper Queen tuyere box is of the duplex type, provided with slag-drainage hole and a quickly removable cap, fastened with swinging lugs. A particular feature of the Copper Queen tuyere connection is the stop-cock or Corliss type of valve in contradistinction to the gate-valve type used by most smelting plants. An advantage of the stop-cock valve is that it works more easily than the gate-valve type and may be closed air-tight. It has a slotted flange on one end, so that by simply loosening the holding bolts, the tuyere pipes may be quickly removed to facilitate repairs or change of jackets. This type of valve is used by several of the smelting plants in the Southwest.

Tuyere Box Used by Detroit at Morenci

The tuyere box used by the Detroit Copper Mining Co. at Morenci, Ariz., is of interest as presenting a refinement of the tuyere cap originating at the Shannon works in the same district. The finger principle is used for holding the tuyere cap in place, but in the Shannon tuyere box the cap revolves on the bolt of the finger; when a tuyere slags, the cap must slide over a face of solidified slag, which is sometimes difficult. In the Detroit design the cap is free to drop out of the way as soon as the finger is lifted. The tuyere cap is attached at the bottom by a loose-fitting hinge. The faces of the cap and tuyere box are machined; when in use they are held together by the revolving finger, which intercepts a wedge on the outer surface of the cap and makes a tight joint. There is a raised ring left on the inner surface of the cap, so as to center it on the tuyere box in case the hinge becomes very loose from wear; this insures a tight joint at all times, and while slightly more expensive at the start, it has the advantage of not wasting compressed air. A slag escape is provided in the bottom of the tuyere box which is attached to the furnace jacket with slotted flanges so that, by loosening the nuts of the holding bolts, the tuyere box and blast pipe may be quickly removed when it is desired to change a furnace jacket. The blast pipe is simply thrust into the stuffing-box of the tuyere box and packed with asbestos.

The tuyeres shown in Fig. 4 are used on the 48-in. by 40-ft. copper blast furnaces of the Calumet & Arizona Mining Co., at Douglas, Ariz. Supt. H. A. Clark writes regarding these tuyere boxes as follows: "They have a taper connection to fit the tuyere thimble in the jacket and an adjustable ball-and-socket connection for the blast pipe. These connections, which are self-seating, make a very simple and air-tight joint and allow of quick removal or replacement. The cleaning door is held with a steel spring latch, and the slag hole is filled with a fiber plate or wooden plug. The tuyere boxes are simple and most serviceable and after several years of operation require absolutely no repairs."

At the Boston & Montana reduction department of the Anaconda company at Great Falls, Mont., Supt. J. H.

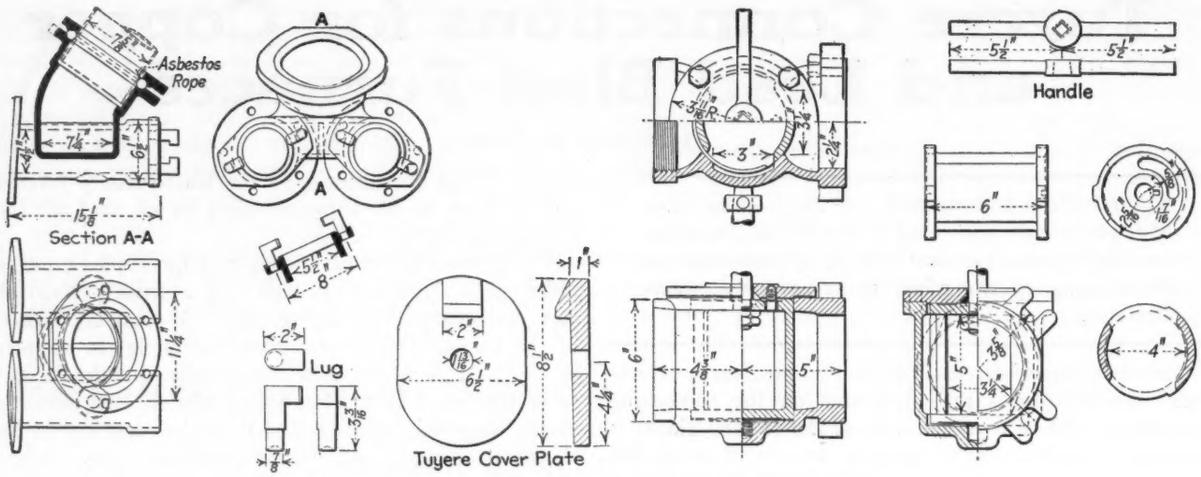


FIG.1 COPPER QUEEN DUPLEX-TUYERE BOX AND STOP-COCK VALVE

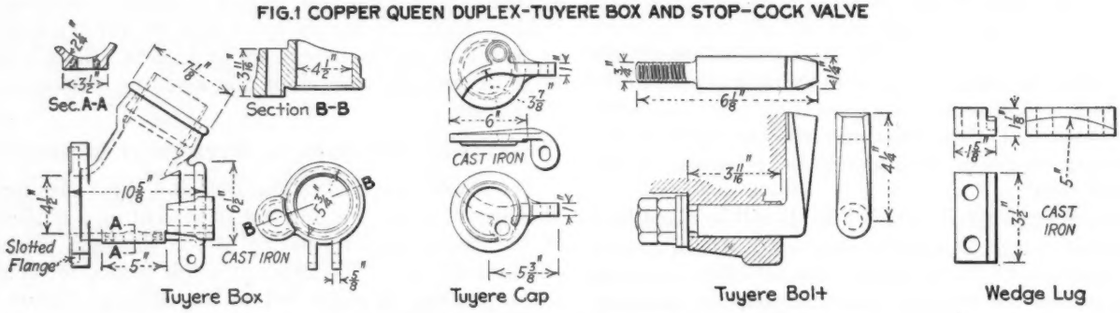


FIG.2 DETROIT COPPER MINING CO'S TUYERE BOX

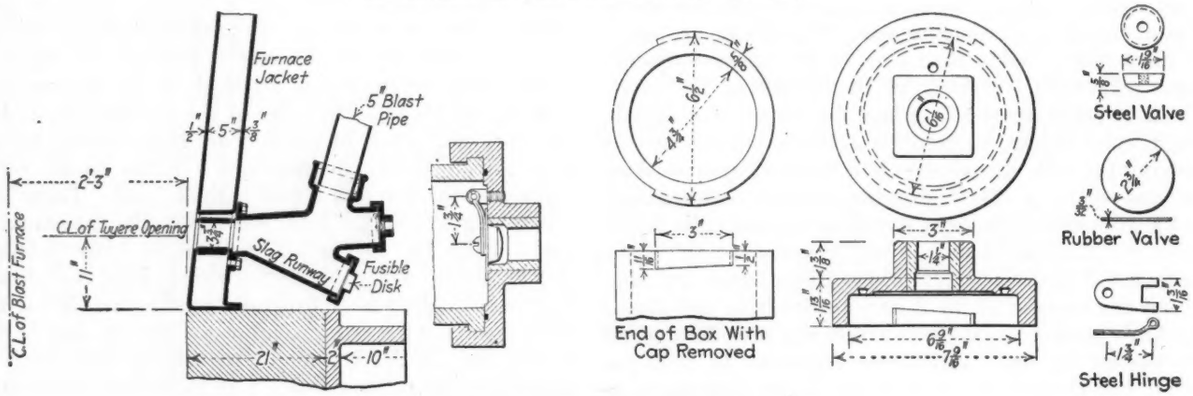


FIG.3 BOSTON & MONTANA STANDARD TUYERE

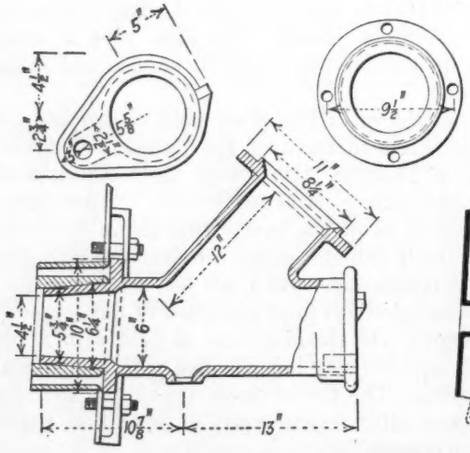


FIG.4 CALUMET & ARIZONA TAPER-FIT TUYERE

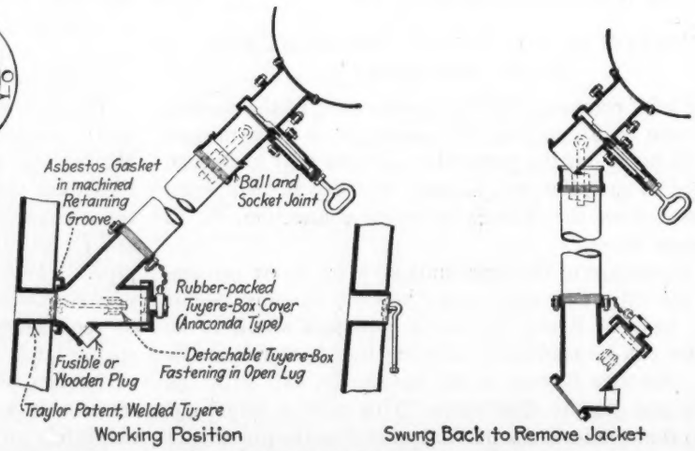
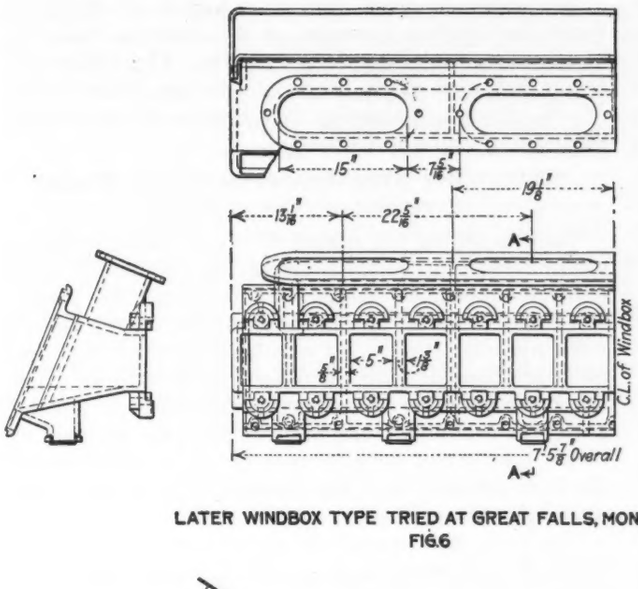
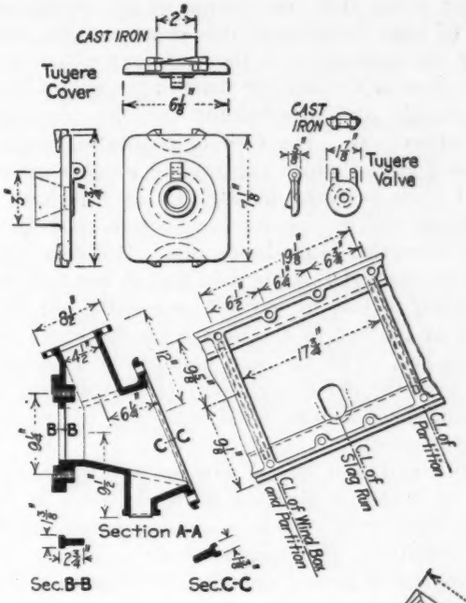

Asbestos Gasket in machined Retaining Groove
Ball and Socket Joint
Rubber-packed Tuyere-Box Cover (Anaconda Type)
Detachable Tuyere-Box Fastening in Open Lug
Fusible or Wooden Plug
Traylor Patent, Welded Tuyere
Working Position
Swung Back to Remove Jacket

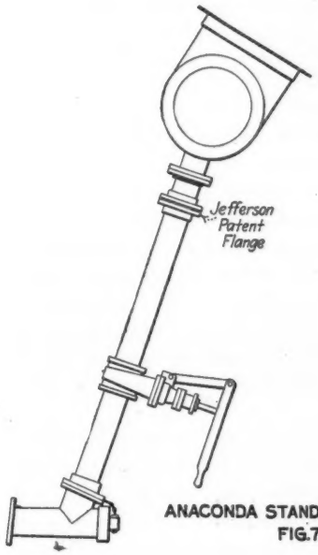
FIG.5 TRAYLOR STANDARD COPPER TUYERE USED AT TRAIL, B.C.

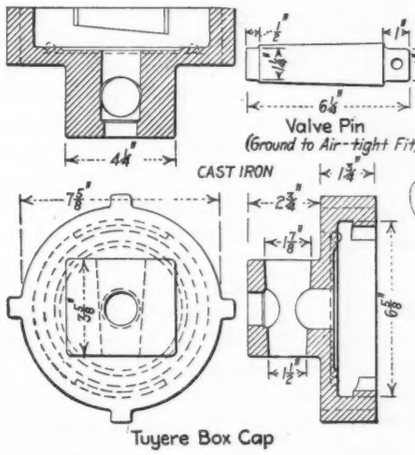
LEADING TYPES OF TUYERE CONNECTIONS AT IMPORTANT COPPER



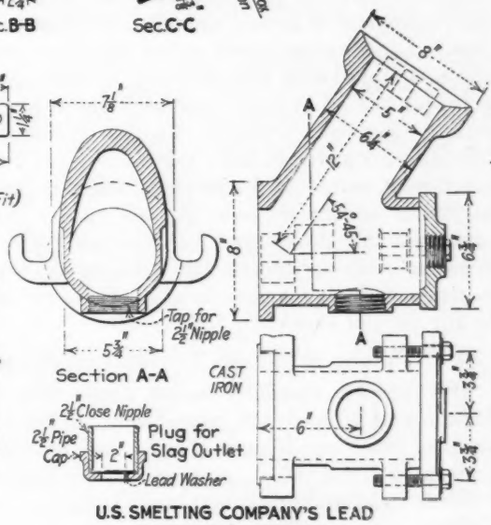
LATER WINDBOX TYPE TRIED AT GREAT FALLS, MONTANA
FIG.6



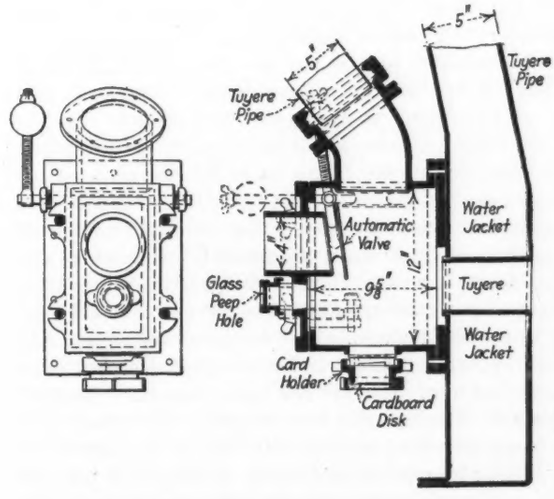




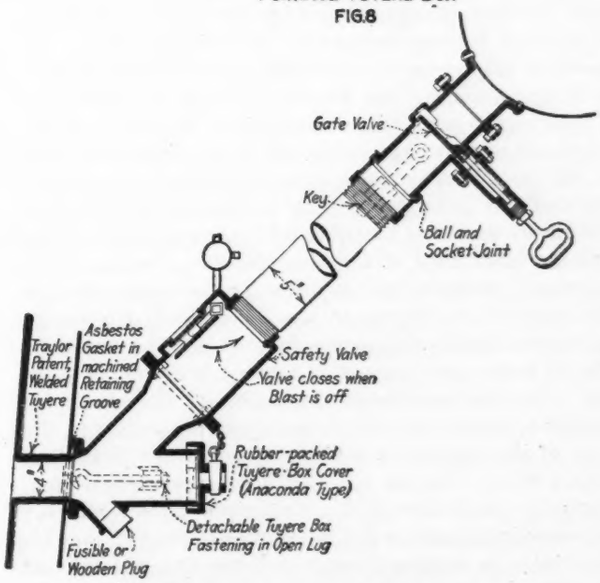
ANACONDA STANDARD TUYERE
FIG.7



U.S. SMELTING COMPANY'S LEAD FURNACE TUYERE BOX
FIG.8



EILERS AUTOMATIC-CUTOFF LEAD TUYERE
USED AT MANY A.S. & R.CO. PLANTS
FIG.9



TRAYLOR STANDARD LEAD TUYERE FOR BUNKER HILL & SULLIVAN'S NEW PLANT AT KELLOGG, IDAHO
FIG.10

AND LEAD BLAST-FURNACE SMELTING PLANTS IN THE UNITED STATES

Klepinger writes that "on account of the curtailment in the use of blast furnaces at this plant and the probable ultimate discontinuance of their use entirely, not much has been done in the last few years in the way of developing apparatus and attachments for the blast-furnace tuyere connections. The type of connection considered as standard and of which the greatest number are in use at Great Falls is shown in Fig. 3. In this form there is a separate tuyere pipe for each tuyere, with its independent connection to the bustle pipe. It differs from the older forms used at this plant in that it has a device for freeing itself of slag by burning or melting out the fusible disk at the end of the branch on the lower side of the tuyere box. This has been found to be a decided advantage over the old straight-bottom tuyere pipe, which would sometimes become filled with slag before trouble would be observed.

"Another and later type of windbox and tuyere connection at the Boston & Montana works is shown in Fig. 6. This has been tried out to a limited extent only and consists essentially of a windbox built in compartments, each compartment having a single connection to the bustle pipe. Each compartment serves three or four tuyeres and is equipped with slag escape at the bottom, covered by a fusible cap to indicate promptly the flow of any slag into the windbox. Owing to the discontinuance of blast-furnace work at Great Falls, this box was not tried out for a sufficient period to determine whether it possesses any particular advantages over the old type. Personally I cannot see that it has any advantages and think that there are some disadvantages in that it might become necessary to renew a whole windbox in case of any serious damage to any part of same."

Traylor Standard Tuyere Connections

The Traylor standard tuyere connections shown in Figs. 5 and 10 are used respectively on the copper furnaces of the Consolidated Mining and Smelting Co. of Canada, at Trail, B. C., and on the new Bunker Hill & Sullivan lead-smelting plant now being constructed at Kellogg, Idaho. These tuyeres are also used by many other smelting plants, being made by the Traylor Engineering and Manufacturing Co., of Allentown, Penn. By reason of its extensive experience in the construction of smelting equipment, the Traylor company has been able to incorporate in its tuyere connections the results of the experience of many engineers, and these connections may be said to represent the approved constructional details adaptable to general smelting conditions in America. The tuyere proper is incorporated by autogenous welding with the inner sheet of the water jacket—a patented feature—and presents less opportunity for water leakage than most of the tuyeres in use. The tuyere-box design embraces a fusible-plug escape for slag, and the Anaconda type of tuyere-box cover with tapered plug in the peephole. The ball-and-socket connection of the blast pipe permits of quick removal of the tuyere connection in the event of the removal of a blast-furnace water jacket. A feature of the Traylor standard lead tuyere connection, adopted by the Bunker Hill & Sullivan and the Northport lead-smelting plants, is the safety valve shown in Fig. 10. This valve is automatic and obviates the necessity of removing the tuyere-box covers in case the blast is cut off, and eliminates automatically the danger of explosions which have occasionally caused much damage at lead smelting plants.

The automatic-cutoff valve is a feature of the Eilers tuyere box used at a number of the American Smelting and Refining Co.'s lead-smelting works. Fig. 9 shows the tuyere box used at the works at Murray, Utah. Supt. W. W. Norton, discussing this feature of the furnace equipment, writes as follows:

Tuyere Box with Automatic-Cutoff Valve Invented by Anton Eilers

"In considering the subject of tuyere boxes, or tuyere connections of any sort, the designer should have in mind adequate mechanical means for preventing the passage of furnace gases up into the tuyere pipes during periods when the blast is off. All who have operated blast furnaces are familiar with the danger incident to an explosive mixture of gas and air within the bustle pipes, this hazardous condition being brought about by shutting off the air blast and at the same time failing to guard against the back pressure from the furnaces. Disastrous explosions have thus occurred.

"Early-day galvanized-iron tuyere nozzles, which connected flexible canvas sacking with the tuyere holes, were safe provided the operators would 'pull the pipes' when a sudden irregularity caused the blast to quit. With larger furnaces and higher blast came rigid steel tuyere pipes and the necessity for a tuyere box of some sort, these 'boxes' being of various shapes and serving to decrease air leakage, also embodying other desirable features. A slide valve operated by hand, either just above the box or up in the tuyere pipe, was usually provided.

"The Murray plant now uses a tuyere box containing an automatic valve as invented by Anton Eilers many years ago. The design has been improved in several respects, but the essential idea of Mr. Eilers is still retained; namely, a valve that automatically prevents a backing-up of gases into pipes and eliminates dependence upon a valve operated by hand.

"The main features are shown in an accompanying sketch. A simple cast-iron box is screwed directly on the jacket. The pressure of the blast entering at *A* holds a disk of the valve firmly against the hole *C*. If the blowing engine stops or the blast suddenly ceases from any other cause, a counterweight forces the valve to change position and the disk firmly closes the hole *B* instead of *C*. Any back pressure of gases out of the tuyere *D* is thereupon immediately permitted to pass out into the open air through *C* instead of up into the tuyere pipes through *B*, and danger of explosions is automatically avoided. So far as my information goes, all other types of tuyere boxes depend upon the human factor in so far as valves at the tuyeres are used to guard against hazards just mentioned.

"The Eilers automatic tuyere box allows freedom of working space in case of an unfortunate necessity to bar out slag from tuyeres. Hinged bolts with thumb-nuts permit the square covers of the boxes to be readily removed, thus affording ample play for bars used in any sort of a cleaning-out operation, a feature that does not exist in tuyere boxes of a more restricted design. Another good feature, although this is a common adjunct of most tuyere boxes of today, consists of a hole at the bottom of the box, closed by a bit of cardboard. If slag runs into the box, the cardboard burns, the slag flows out the hole and the furnaceman at once 'gets busy.'"

The latest form of tuyere box developed at the United States Smelting Co.'s plant at Midvale, Utah, is shown in Fig. 8. Supt. L. D. Anderson, in commenting on

this, writes: "I cannot say that there is anything particularly brilliant or meritorious about this tuyere box, other than that it has been found satisfactory and serviceable. The original tuyere box was provided with a cap which clamped on the face. In the present design this cap is held on by two capscrews. The reason for this change was that in the case of slagging in the old tuyere box the face against which the cap fitted sometimes became scarred, permitted air leakage. As the cap was held on by clamp lugs, there was no way of cleaning up this face, and the old box would have to be discarded in order to avoid leakage of air. With the present design, if the face becomes scarred it is a simple matter to put the casting in the lathe and turn off the face so that the box can be put back into service. There has also been added an opening for slag escape, which has proved very useful. The drawing calls for a lead washer. As a matter of fact, pieces of pasteboard are plenty good enough for this purpose and are regularly used at this plant."

Basic-Lined Converter Practice

Basic converting in the Southwest was probably first attempted in 1907 by the late Charles F. Shelby at the reduction works of the Cananea Consolidated Copper Co. Having replaced the acid lining of an 8x12-ft. barrel-type converter with one course of magnesite brick, he blew only 21 taps (about 180 tons) of matte to white metal before the brick gave out along the tuyere line. The lining cost $700, and the experiment was abandoned as impractical. No further effort to bessemerize copper mattes in vessels equipped with more or less permanent linings of basic brick were made by any of the large companies in the Southwest until some months after Messrs. Peirce and Smith had proved basic-lining a metallurgical and financial success by their work at Baltimore and Garfield.

The year 1911 is noteworthy as the one in which many companies did their first successful work with basic-lining. The Cananea Consolidated had several converters in operation with basic lining in this year and in the 18 months following blew 50,000 tons of copper with them. The Consolidated Kansas City Smelting and Refining Co. installed two 10x26-ft. Peirce-Smith converters in September at its El Paso plant. In March, 1913, one standard Great Falls type converter was added. At its Hayden, Ariz., plant, two 10x25 Peirce-Smith converters were added in 1911, followed in 1913 by one Great Falls converter.

It was during 1911 that the Anaconda Copper Mining Co. proved the worth of the so-called Great Falls converter. It was to this type, now recognized as standard, that the Copper Queen company turned in 1912 when it was decided to equip the Douglas reduction works with basic-lined converters.

In October, 1911, the Arizona Copper Co. first used the basic-lined converter at the old Clifton plant and continued the use of small basic-lined converters until October, 1913, when the new smeltery was equipped with three stands of electrically operated Great Falls converters.

The Old Dominion company installed a 12-ft. Great Falls converter in January, 1913, supplemented when necessary by two small basic-lined converters. The Detroit Copper company has never considered it advisable to adopt the large basic-lined converter, but instead has equipped its 7x10-ft. converters with basic lining. A record has been made in converting over 3,100,000 lb. of copper with one lining before any patching of the brick was necessary. The Consolidated Arizona Smelting Co. at Humboldt has likewise continued the successful use of small basic-lined converters, but now contemplates the purchase of a large unit.

Both the International Smelting Co. at Inspiration, and the United Verde, at Clarkdale, have installed the standard Great Falls electrically operated converters in their new plants, which went into operation in 1915.

There is no question about the superiority of basic over acid linings or, where the output of copper is sufficiently large to insure efficient operating, of the standard type

TABLE 1. OPERATING DATA OF BASIC-LINED CONVERTERS IN SOUTHWEST

	1	2	3	4	5	6	7	8	9	10
Blast pressure in pounds	13	13.2	14	12	12.4	12–15	10–14	14	11.3	13
Cu.ft. air per minute per converter	5,445	7,691	10,600	4,283	6,054	7,250		8,181	4,033	4,117
Cu.ft. air per ton bullion produced	152,449	178,411	141,000	228,116	271,577	137,582	118,328	225,674	245,975	370,566
Cu.ft. air per ton iron and sulphur oxidized	96,145	142,224	156,000	98,847	139,361	112,950	118,328	119,475	240,937	123,583
Oxygen efficiency, taking into account total iron and sulphur oxidized	84.0	54.1	57.2	76.8	56.3	74.0	81.0	50.6	69.8	59.0
Total tons iron and sulphur oxidized per stand per month	2,075	1,610	.....	1,647	1,903	2,868	1,991	2,576	768	1,440
Punchers used per shell per shift	2	2	2	2	2	2	2	1	1.5	2
Tons bullion per puncher per month	221	204	522	119	478	392	255	137	129	240
Tons iron slagged per puncher per month	192	153	.....	169	533	251	171	156	147	.....
Average time of blow, hours and minutes	4–00	4–11	3–09	6–44	9–20	8–00	8–30	7–12	4–51	10–00
Average time to blow one ton bullion, minutes	28	23	14	54	45	19	28	28	51	90
Average tons bullion per blow	8.5	10.8	13.3	8.22	12.7	25.3	18.0	15.6	5.8	6.7
Average weight of matte per charge, tons	21.9	26.0	25.9	33.9	40.5	60.0	50.0	51.2	19.7	26.6
Tons ore charged per ton of matte	0.23	0.20	0.155	0.201	0.17	0.25	0.30	0.21	0.286	0.283
Tons iron slagged per ton of available silica	.....	2.44	.....	2.45	3.85	1.75	1.80	2.36	2.03	2.60
Size of converters	12 ft.	12 ft.	12 ft.	12 ft.	12 ft.	10 x 26 ft.	12-ft. Gt. Falls 10 x 26 ft. P.-S.	12 ft.	7 x 10½ ft.	9 x 7½ ft.
Number of tuyeres	28	24	24	24	24	35	24 Gt. Falls. 35 P.-S.	22	12	12
Size of tuyeres, inches	1¼	1¼	1¼	1¼	1¼	1¼	1¼ Gt. Falls 1¼ P.-S.	1¼	1¼	1¼
Thickness of brick used on tuyere line, inches	24	30	30	14	30	18	18	24	18	15
Average slag analysis:										
SiO_2	19.6	21.7	17.2	17.4	15.6	23.6	25.7	29.2*	22.2	23.8
FeO	68.2	67.9	69.1	70.7	67.3	66.2	60.0	62.1	63.4	61.5
CaO	0.8	1.1	0.6	0.8	0.4	.....	.....	1.6	0.9	.....
Al_2O_3	3.4	3.0	3.7	3.0	2.9	.....	.....	.....	2.8	.....
Average matte analysis:										
Cu	37.7	43.37	51.2	28.22	34.7	43.7	42.8	31.9	35.21	25 0
Fe	32.5	29.2	21.6	30.9	34.9	28.0	27.4	28.8	36.1	46.0
S	27.4	23.5	24.5	25.3	24 9	25.1	25.6	18.7	25.0	25 0

1. Arizona Copper Co., Clifton, Ariz.
2. Old Dominion Copper Mining and Smelting Co., Globe, Ariz.
3. International Smelting Co., Inspiration, Ariz.
4. Calumet & Arizona Mining Co., Douglas, Ariz.
5. Copper Queen Mining Co., Douglas, Ariz.
6. Consolidated Kansas City Smelting and Refining Co., Hayden Plant, Ariz.
7. Consolidated Kansas City Smelting and Refining Co., El Paso Plant, Texas
8. Cananea Consolidated Copper Co., Cananea, Sonora, Mex.
9. Detroit Copper Mining Co., Morenci, Ariz.
10. Consolidated Arizona Smelting Co., Humboldt, Ariz.

* Insoluble.

*Abstract from "The Basic-Lined Converter in the Southwest," a paper presented at the Arizona meeting of the A. I. M. E. by L. O. Howard, Globe, Ariz.

over the smaller basic-lined converter. The inability properly to control the temperature of the charge in the small vessel, and the resulting destruction of the brick lining, are the most serious difficulties with which the operator using a small basic-lined converter has to contend. Throughout the Southwest, the preference has been for the standard upright rather than for the horizontal converter. The greater flexibility of the former and the greater ease with which repairs may be made strongly recommend it.

TABLE 2. OLD DOMINION COPPER MINING AND SMELTING CO.

Campaign of basic-lined converter No. 2	December, 1915
Put in operation	June 27,1913
Removed for initial patching	Dec. 7, 1915
Total hours blowing	13,734
Total number blows made	3,288
Average time of blow	4 hr. 11 min.
Total number taps matte	9,316
Total tons matte charged	85,578
Average weight of matte per charge	26 tons
Average copper content of matte	43.37%
Total tons bullion produced	35,431
Average time to blow one ton copper	23.2 min.
Average tons copper per blow	10.80
Average blast pressure	13.2 lb.
Average air used to blow one ton copper	178,411 cu.ft.
Average air used per minute	7,691 cu.ft.
Average air used per ton iron slagged	242,502 cu.ft.
Total ore fed	17,097 tons
Tons ore fed per ton matte blown	0.200
Magnesite used for repairs	None

Average Slag Analysis Cu, 2.1%; SiO_2, 21.7; Fe, 52.2; CaO, 1.1; Al_2O_3, 3; S, 1.8.

Average Matte Analysis Cu, 43.37%; Fe, 29.2; S, 23.5.

The operating data in Table 1 will give an idea of the working conditions and the results obtained at some of the large smelting plants in the Southwest. It is to be regretted that replies to questions pertaining to power consumption were at such variance that it was thought best to omit them entirely, as no reconciliation seemed possible.

Separate operating data for the Peirce-Smith and Great Falls converters at El Paso could not be obtained, so the figures in column 7 are a combination of results obtained in these different types. The figures in columns 9 and 10 are for former acid-lined shells now operating with a lining of magnesite brick. All figures are for periods of a month or more. Those in column 5 are for 1915. The data in column 2 cover a period of 29 months' operation—the life of one original lining to the time of first patching.

Data relating to a campaign of a lining at the works of the Old Dominion are given in Table 2. The tabulated results contrasted with those of the first experimenters fairly measure the advance of the art in a few years time.

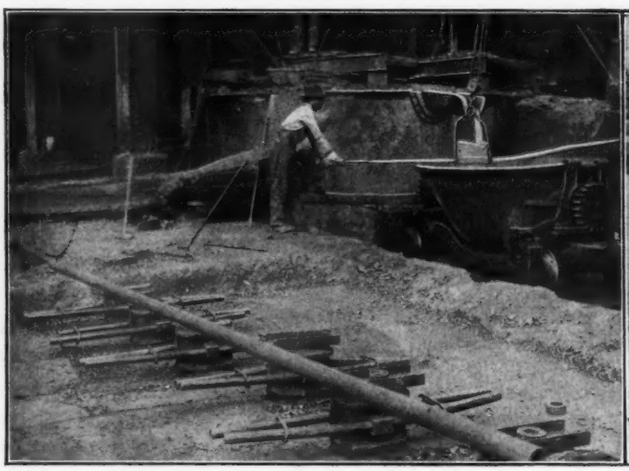
Slag Lining for Launders

By W. A. Leddell*

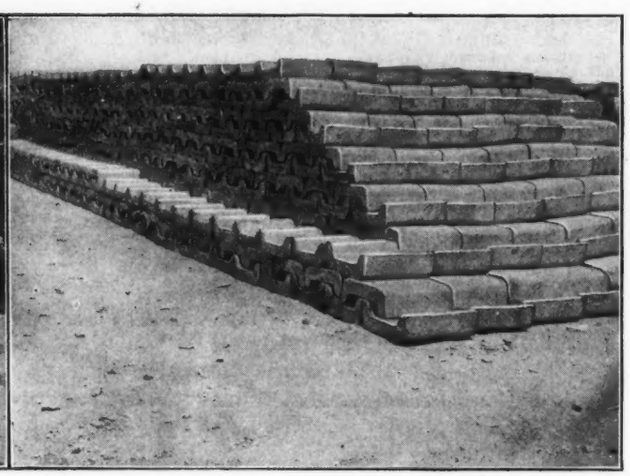
Acid water in concentrator work in some parts of the country is the direct cause of high repair costs on launders, pumps, screens and grinding equipment. On launders that carry coarse material erosive action is particularly heavy. Iron or glass liners are frequently used to prevent this action. Where acid water is encountered, the iron is attacked and the grinding action of the pulp materially assists the rapid destruction of the liner. Glass is more permanent but expensive—especially where freight rates are high.

Attempts have frequently been made in times past to utilize blast-furnace slag by casting it into large bricks. These, however, have been unsuitable for lining launders for various reasons, but particularly because of excessive weight on the framework and supports when long, elevated launders were required. This objection would of course not hold if the slag were cast into liners from 1 to 2 in. in thickness; a 12x12x2-in. liner would then weigh less than 40 lb. This may be successfully used, provided the block thus cast will withstand a reasonable amount of handling.

A liner sufficiently substantial to fulfill these requirements was suggested and developed[1] by me at Morenci, Ariz., for the Detroit Copper Mining Co. These liners are now in use at that plant and also I believe at that of the Old Dominion Copper Co., of Globe, Ariz. The former plant now has in service upward of 25,000 ft. of this type of lining.



CASTING LEDDELL SLAG LINERS



CHANNEL-SHAPED LINERS FOR LAUNDERS

Slag, to be serviceable for this work, must be both reinforced and annealed. The reinforcement used is common poultry netting, 1-in. or 1½-in. hexagon mesh, 26- or 28-gage wire. The casting is done in a metal mold. This enables one to use common labor for producing the slag liners The castings are made on end; that is, the mold is open at both ends and stands on a cast-iron floor plate which closes the bottom. The top is covered with a plate with a hole in the center of a short riser, which forms the gate through which the slag is poured.

Two pieces of reinforcing mesh are placed in the mold before pouring, one piece near each side; that is, not on

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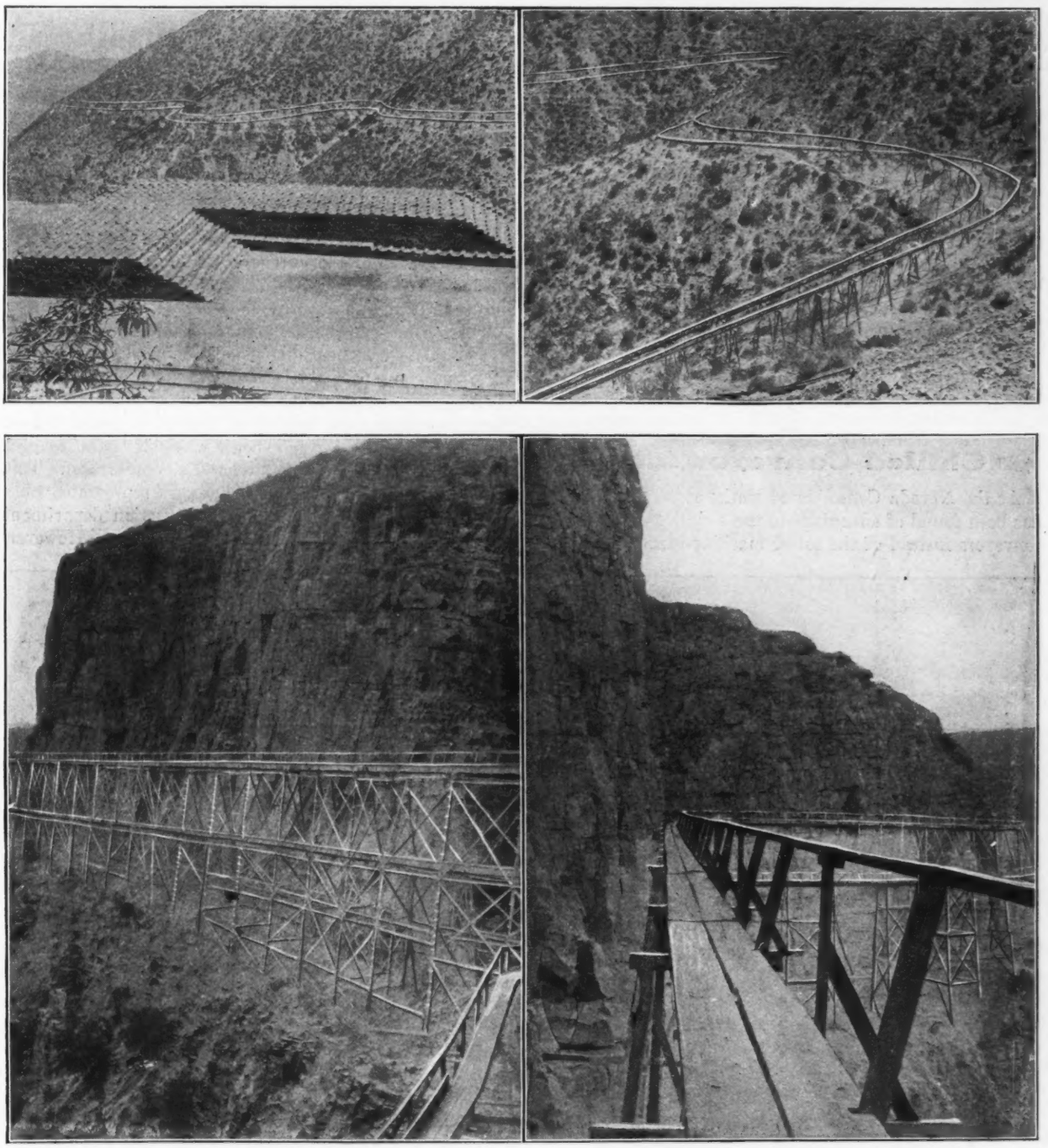
[1]U. S. Pat. 1,189,842, July 4, 1916.

the neutral axis of the casting. The wire then acts as reinforcement. As soon as the slag chills slightly, in fact while the center of the casting is still in a fluid state, it may be removed from the mold. It is then laid on the ground and covered with a thin layer of some nonconducting material such as sand, lime, etc., after which another casting is placed on top with another covering of sand.

The cost of this type of lining is only a small fraction of that of cast-iron or glass lining. Slag lining per foot should not cost more than 12c., while the iron lining will cost from 90c. to $3, depending on the thickness, price of iron, freight, etc.

Comparative costs at Morenci on the slag and cast-iron liner is obtained over a period of 2½ years show a saving



TWO TAILING FLUMES OF THE DETROIT COPPER MINING CO., AT MORENCI, ARIZ., ARE LINED WITH SLAG

Each flume, about 10,000 ft. in length, is protected with Leddell slag liners, which are calculated to wear six years, as against yearly renewal of 2-in. plank lining. In all about 25,000 lin.ft. of slag liners are in use by the Detroit company

This is done in order to retain as long as possible the heat in the casting, thus reducing shrinkage strains. At this point it might be well to mention that channel-shaped liners should be, as nearly as possible, of uniform thickness.

in the 1,500-ton concentrator of upward of $6,000 per year. In addition to the concentrator work proper the company later lined the tailings flume with slag. This was an expensive piece of work since it was inaccessible except from either end of the 2-mi. flume. The completed

work, however, effects a large yearly saving in addition to that already produced in the concentrator. A report, dated July, 1915, in regard to the slag liners, which had then been in use about one year, says:

The following is a record to date of slag lining in comparison to cast iron:

Year 1912—Cast-iron, only.....	$7,015.00	= 0.01397 per ton
Year 1914—Cast-iron and slag, both.	1,873.50	= 0.00407 per ton
Jan.-July, 1915—Slag only.....	498.13	= 0.00197 per ton

Cast-iron liners from rolls to elevator, average life, 90 days; slag liners for same service, 180 days. Cost per foot of cast-iron liners, $0.90, as against $0.12 for slag.

Cast-iron liners, feed launders to Wilfley tables wore 60 days, against 240 days (and still in service) for slag. Slag liners put in July, 1914, on finer material, still in service and good for several months yet. Life of cast iron, same service, 180 to 210 days.

The very satisfactory result that we have obtained from slag liners has resulted in our lining two tailing flumes 10,000 ft. in length each with slag. On this service we figure the slag will wear six years as against former yearly lining of 2-in. plank.

Acid water, with which we have to contend, has no effect whatever on slag liners, whereas on cast iron its action is heavy. In all we will have in service when the change is complete a total of 25,000 lin.ft. of slag liners.

Slag lining for chute bottoms has also proven economical where the materials handled were not coarse enough to produce a heavy shock on the slag lining. At Morenci material up to 5/8-in. was handled successfully with this lining.

Chilled Conveyor Idlers

At the Nevada Consolidated works at McGill, Nev., it has been found of advantage to use a chilled idler for belt conveyors instead of the softer machine-turned idler supplied by the belt-conveyor manufacturers. The relative values of the chilled idler and the machine-turned idler are clearly shown in the accompanying halftone engravings made from photographs of the two kinds of idlers taken after actual service. Fig. 1 shows a set of all chilled idlers that had been in identical service with the set of all factory-made soft-metal idlers shown in Fig. 2. Fig. 3 shows a combined set with factory-machined idlers on the sides and a hard chilled idler in the center.

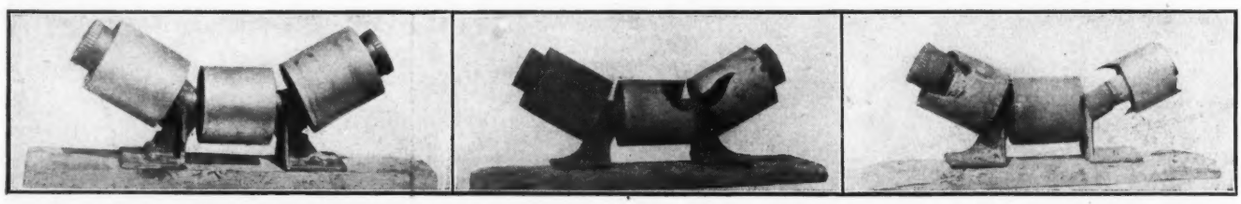
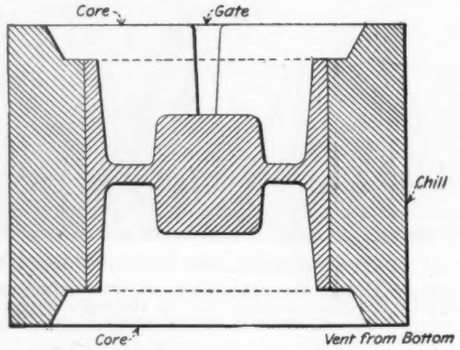


FIG. 1. CHILLED IDLERS FIG. 2. SOFT MACHINED IDLERS FIG. 3. CHILLED CENTER IDLER

Idler sets shown in Figs. 1 and 2 were in service the same length of time and on the same conveyor; note superior wearing qualities of the chilled idlers. This is again demonstrated in Fig. 3, where the chilled idler in the center outlasted the other two soft, machine-finished idlers



METHOD OF CASTING CHILLED IDLERS

The method of casting the chilled idler for the Nevada Consolidated conveyors is shown in the line drawing. The idler is not turned, but is cast smooth enough to require no finish whatever. The casting is put into a lathe, centered and drilled, and is then ready for service.

Structural-Steel Estimations

By E. R. Rankin, Jr.*

There are three forms in which data for estimating structural-steel work for mining plants are submitted to prospective bidders. These forms may not be called systems, because they partly overlap, and while any purchaser may adopt as general practice one or another of them, all three will in time be utilized. However, two of them are extremes and, as such, offer obstacles to correct estimating or are wasteful of the purchaser's time and money. The various forms are: First, outline diagrams; second, design drawings; and third, shop details.

The outline diagram is no more than a sketch showing horizontal and vertical dimensions of the proposed structure, the columns possibly being located, but with wall openings practically never shown. The adoption of this form necessitates the receipt of tenders in pound prices. It throws the engineering expense where at times it rightfully belongs—outside the purchaser's organization. This course is necessary if the purchaser is represented only by a mechanical-engineering or construction department not qualified properly to handle steel design. However, the outline diagram, meager in data and often vague, leads to wide variations in estimated weights and quotations among the bidders, and sometimes to consequent readjustments of cost budgets.

For one instance of the effect of obscurities, different standard assumptions for maximum wheel loads and length of wheelbase for a traveling crane would, in a runway of not unreasonable length, affect the cost through the design of the supporting girders and columns to an extent comparable to the cost of the crane itself.

Experience and Good Judgment Valuable

Snap-judgment cost estimating is demanded where experience and good judgment would repay better their users. If wide variations in the class and cost of fabrication occur in several structures embraced in one pound-price contract, a disadvantage is worked if, when making final and complete designs, the comparative tonnage of different classes is changed from the proportions originally fixing the average price. This may be obviated by basing the contract on certain agreed estimated weights

*Box 85, El Paso, Tex.

for each structure, the final variation either way being subject to separate unit prices.

The first form improves by taking on the nature of the design drawing. All data, except stresses and sizes of material, transferred to an otherwise clear and definite line diagram, help greatly in figuring approximately correct weights.

Detail drawings ready for the shop are the other extreme. When they are prepared and submitted for bids, a saving in time may possibly be secured if the related engineering-office work is directed with that end in view. However, while general design drawings (not yet discussed) do not interfere with the use of standards in shop practice, detail drawings furnished by a customer may cause extra expense in fabrication, since in details generally appear the distinct standards fixed by the various shops. The purchaser may pay his engineering office for preparing shop details and then pay the fabricator for remaking them.

The adoption of this form often hinders the use of that worthy expedient, "Substitutions of sizes are permitted where clearances are maintained and the strength of members is not materially affected." If changes in the sizes of material specified are advantageous and permissible, the detail drawings may have to be revised.

The chief use of shop drawings so furnished is in the saving of time at the expense of engineering labor. In the matter of drafting-room costs it is impossible to find any mining company able to compete with the responsible structural manufacturers.

It is not, and cannot be, denied that the design drawing with skeleton specifications is the most profitable means of submitting the required information to bidders. The specifications should state no less than the following points: Proper assumptions for dead and wind loads; definite statements of live loads and the conditions of their application; maximum allowable unit stresses; and typical or special details where required. Supplementary to this information should be reasonably well-defined time allowances for supplying or erecting. Mere instructions that bidders should state how soon they can supply and that delivery will influence the award of the work is not sufficient to prevent a bidder submitting a hit-or-miss proposition.

Details Required for Estimates

If erected figures are asked, information is necessary making clear the cost of unloading and handling to sites, also as to the availability of power, air or steam and at what unit cost. The kind of paint should be specified and no discrepancies permitted to obscure the character of field work, riveted or bolted connections, etc. If other materials are to be included with the structural-steel work, as is so often the case, the specifications covering them should be equally complete and definite, or the good work done by one hand may be nullified by the other. Such matters as deciding upon the most satisfactory and economical type and thickness of siding and roof covering, the location and extent of window openings, character of sash and glazing, the form of ventilators and amount of ventilation to be secured should not be put up to prospective sellers unfamiliar with the conditions affecting particular cases.

The purchaser should also assume responsibility for all required arbitrary treatment of design based, not on engineering computations, but on experience—the possible action of molten metal, or radical and repeated changes in temperature, as well as the more obvious corrosive effects of smoke and dust.

Both lost time and multiplied selling expense result from requests for designs with proposals, even when purchasers submit complete and definite data facilitating the bidder's work of preparation. However, the stimulation of this kind of competition, when not used to excess, offsets any hardships imposed upon bidders and should result in direct and obvious economical advantage to the buyer.

When steps taken in coöperation between purchasing and engineering forces result in the saving of time and reduction of selling costs, "scientific buying" becomes a reality and achieves tangible benefits for the user.

"Have you ordered your crane? If so, please send us a sketch of the clearance diagram."

"What is the weight of your ore per cubic foot?"

"Do you not consider it inadvisable to lay a corrugated-metal roof on so flat a pitch?"

"You state the table-floor load is to be taken at 200 lb. per sq.ft. Is this inclusive or exclusive of the weight of the concrete floor slab?"

These typical queries illustrate causes of delay and needless correspondence. Every precaution taken along the suggested lines increases the "personal" power of the buyer. Either metals are low or steel is high, and the need is ever present for the exercise of economical standards of procedure in this and allied transactions.

International Smelting Co., Operating Data

The following data relative to the operations of the International Smeltery at Miami, Ariz., were presented to the members of the A. I. M. E. during their recent visit to the works.

Miami and Inspiration concentrates are received, sampled and introduced into the drier plant, which consists of five Wedge furnaces used as driers. The gases are treated in a Cottrell dust-precipitating plant. A drier charge consists of 84.9% concentrates, 0.2% crushed ore, 7.1% converter secondaries, 2.1% pyrite and 5.7% limestone; 207 tons of charge is treated per furnace day, with an oil consumption of 5.51 gal. per ton. The charge contains 28.43% copper.

The calcines are treated in three 21x120-ft. reverberatory furnaces. The charge consists of 71.6 to 82.4% concentrates, 0.3 to 0.4% siliceous ore, 7.3 to 8.4% converter secondaries, 0.4 to 0.5% converter flue dust, 2.3 to 2.6% pyrite, 5 to 5.7% limestone and hot converter slag up to 13.1% to fill out the change. Per furnace day 484 tons is treated at an oil consumption of 0.79 bbl. per ton of charge.

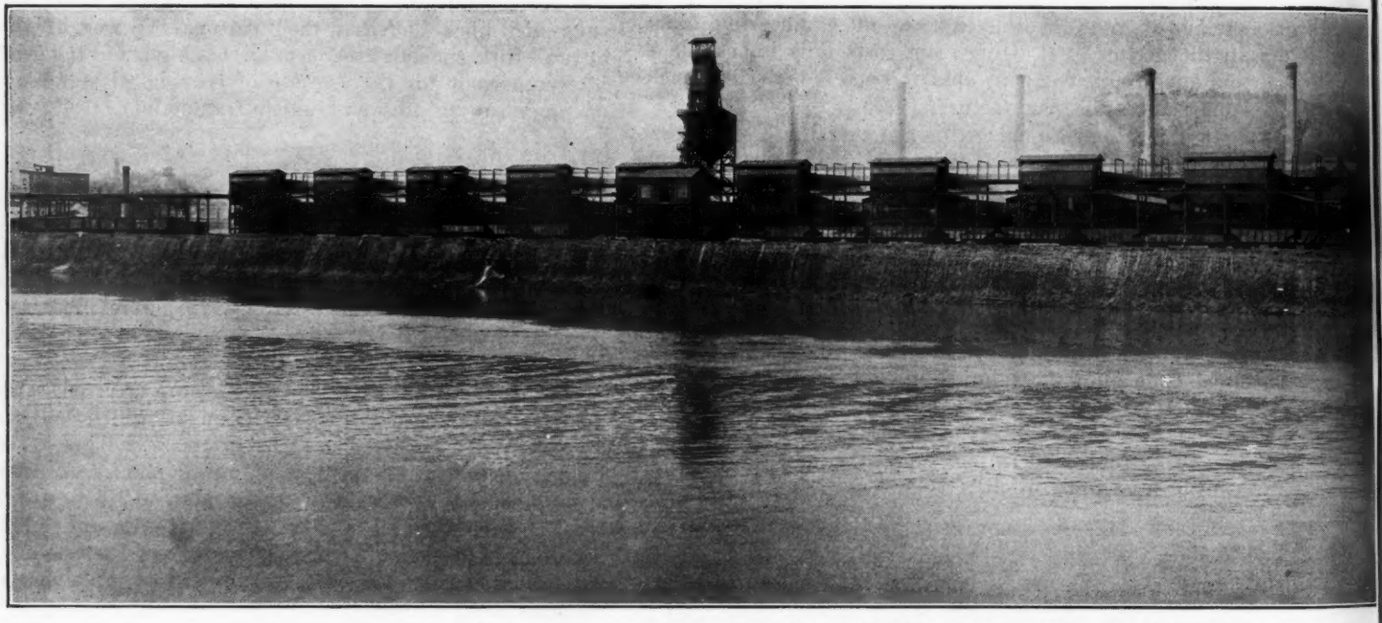
The matte from the reverberatories goes to five converters of the Great Falls type operating under a blast pressure of 12 lb. The average weight of matte per charge is 26.9 tons carrying 51.05% copper from which 13.7 tons of copper is produced. From each converter 95 tons of copper is produced per day. The casting machine has a capacity of 259 tons of copper bars per day. These bars weigh 274 lb. each.

The Donora Zinc Works

By W. R. Ingalls

SYNOPSIS—A description of the Donora Zinc Works of the American Steel and Wire Co., built in the Pittsburgh district last year. All records for construction speed were broken, and a highly refined, modern plant has been built. Its location is commercially favorable. Being operated in connection with the Donora steel plant, advantageous coöperation in respect to administration, power, coal supply, etc., is possible.

The Donora Zinc Works of the American Steel and Wire Co. (a subsidiary of the United States Steel Corporation) is the most recent of zinc smelting constructions in the eastern part of the United States, and it is the largest plant in which coal is the fuel. It is remarkable also for the excellence of its construction and the speed with which is was executed. The provision of this plant, together with the smelteries at St. Louis, Mo., and Cherryvale, Kan., previously owned by the American Steel and Wire Co., gives the Steel Corporation the largest part of the spelter that it requires for galvanizing and other purposes.



PANORAMIC VIEW, FROM THE EAST BANK OF THE MONONGAHELA RIVER, OF

In the construction of the Donora plant, all records for time of building were beaten. Work was begun on June 22, 1915. The first duty was the removal of a pile of 75,000 tons of iron ore standing where the zinc plant was to be. Some grading had to be done, but the amount was not large in proportion to the size of the plant, the site being on the natural bench forming the west bank of the Monongahela River. In starting a zinc smeltery the determinative factor is usually the construction of the pottery and the manufacture of a stock of retorts sufficiently well seasoned, with which to begin. In the case of Donora this difficulty was overcome by bringing the first retorts from Cherryvale, Kan. This explains the mystery that has exercised zinc smelters of how it was possible to begin the production of spelter in less than four months after breaking ground. With the mystery brushed away, the achievement is none the less remarkable. The first zinc was made on Oct. 20, 1915; the first sulphuric acid on Dec. 23, 1915, the zinc smeltery being operated on calamine in the meanwhile.

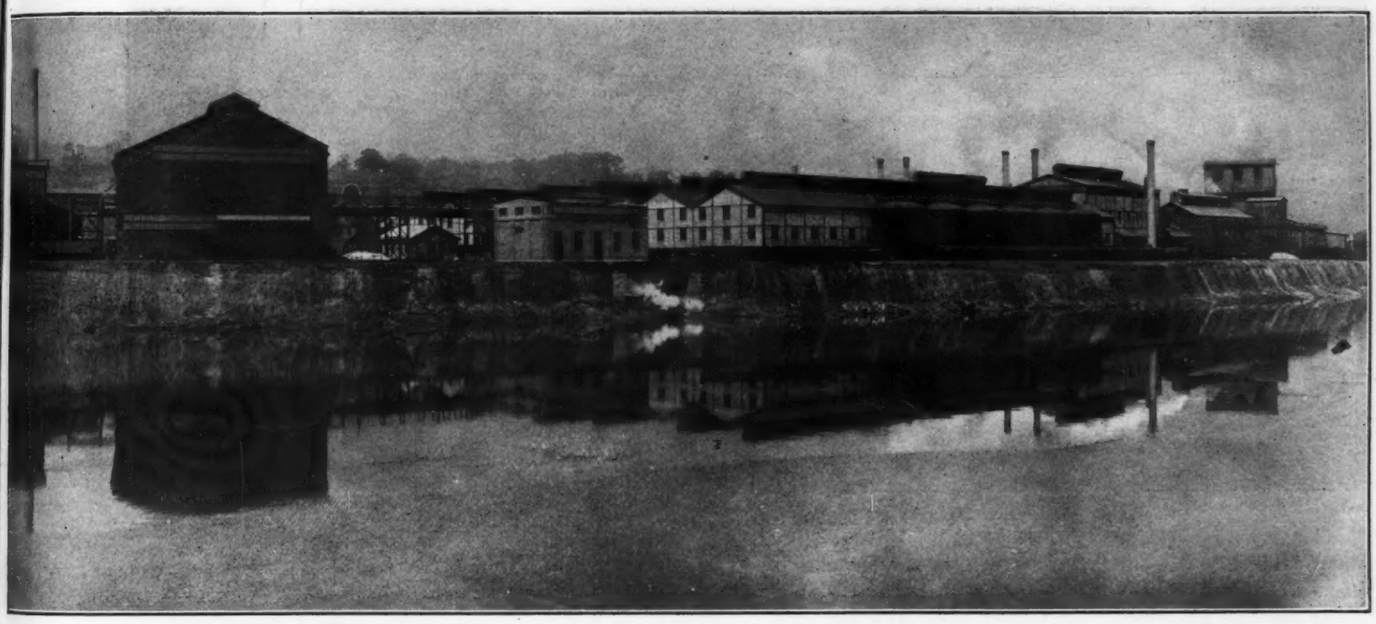
The Geographical Location

In selecting the Pittsburg district for the location of its new plant, the officials of the Steel Corporation showed great wisdom. This district is preëminently the great center of spelter consumption in the United States. Also it is a great consumer of sulphuric acid and lead—both of them byproducts of zinc smelting. Moreover, it possesses a great supply of some of the best gas coal, which is obtainable at relatively low cost; from the anthracite fields of eastern Pennsylvania it can draw the best reduction material; and right in Pittsburgh are manufactured some of the best refractory products. With regard to bringing ore to the works, freight rates in the United States are always lowest on such raw material and rise with the products thereof according to their degree. Zinc ore is generally concentrated and contains but little worthless gangue on which freight is wasted. So long as a zinc plant does not overstep the center of gravity of consumption and run the risk of having to pay back freight (that is, western freight) on the spelter, the farther east it can be situated is generally the better, of course assuming that smelting conditions are equal; for it comes to about the same thing whether freight is paid on the ore to St. Louis and thence on the spelter to Pittsburgh or is paid on the ore all the way to Pittsburgh; but the Eastern plant has a superior command of ores,

not only from the United States, but also from foreign countries. The last has been well exemplified by the experience of the Donora works in getting a large supply of Australian ore.

In the case of the Steel Corporation the Pittsburgh district was a logical selection for internal reasons. The subsidiaries of the corporation are themselves large consumers of spelter—in the aggregate their spelter consumption is the largest of the United States. Also they are large consumers of sulphuric acid. Finally, it was possible to build the plant in connection with some other great plant, thus dividing administrative expense, simplifying the matters of power supply, coal supply, etc., and furnishing a use for the large steam power that could be generated from the waste heat of the smelting furnaces. No doubt these factors all entered into the considerations of the officers of the Steel Corporation in locating the Donora zinc works.

The site of the Donora plant comprises about 40 acres, situated between the Monongahela division of the Pennsylvania R.R. and the Monongahela River, which here runs practically north and south. The zinc smeltery is immediately adjacent to and north of the wire and rod mills of the American Steel and Wire Co. at Donora, the two blast furnaces and the openhearth steel plant of the company being farther south, up the Monongahela River. The entire plant of the company at Donora stretches along the river for about three miles.



THE DONORA ZINC SMELTING PLANT OF THE AMERICAN STEEL AND WIRE CO.

It will be observed, from the accompanying drawing, that the railway system in the Donora plant is extremely simple, the single line serving to bring in the ore and coal and take out the spelter, nothing else being required of it. Transportation from department to department within the works is done by means of an overhead telpherage system, whereby the ground is kept clear of tracks, switches, etc. This creates a pleasing appearance.

The ore cars are brought in over a railroad track scale of 150-ton capacity. The cars are unloaded into 10 storage bins, each being 70 ft. long, 20 ft. wide and 16 ft. deep and having a storage capacity of about 2,000 tons, or 20,000 tons in the aggregate. These bins are concrete-lined, covered by a commodious and well-constructed shed. The distribution of the ore among the bins, and the reclaiming of it, are done by means of a 15-ton overhead electric traveling crane with a grab-bucket. During the unloading of the cars the ore is sampled by the reservation of every tenth shovelful, which is sent to the sampling mill, where it is cut down in the usual manner.

The ore is picked up from the storage bins as required and put through the crushing plant, receiving a preliminary drying in Ruggles-Coles driers, of which there are two. Otherwise the crushing plant is quite conventional and does not require any special description. The crushed and screened ore goes, of course, to the roasting furnaces.

Roasting Department

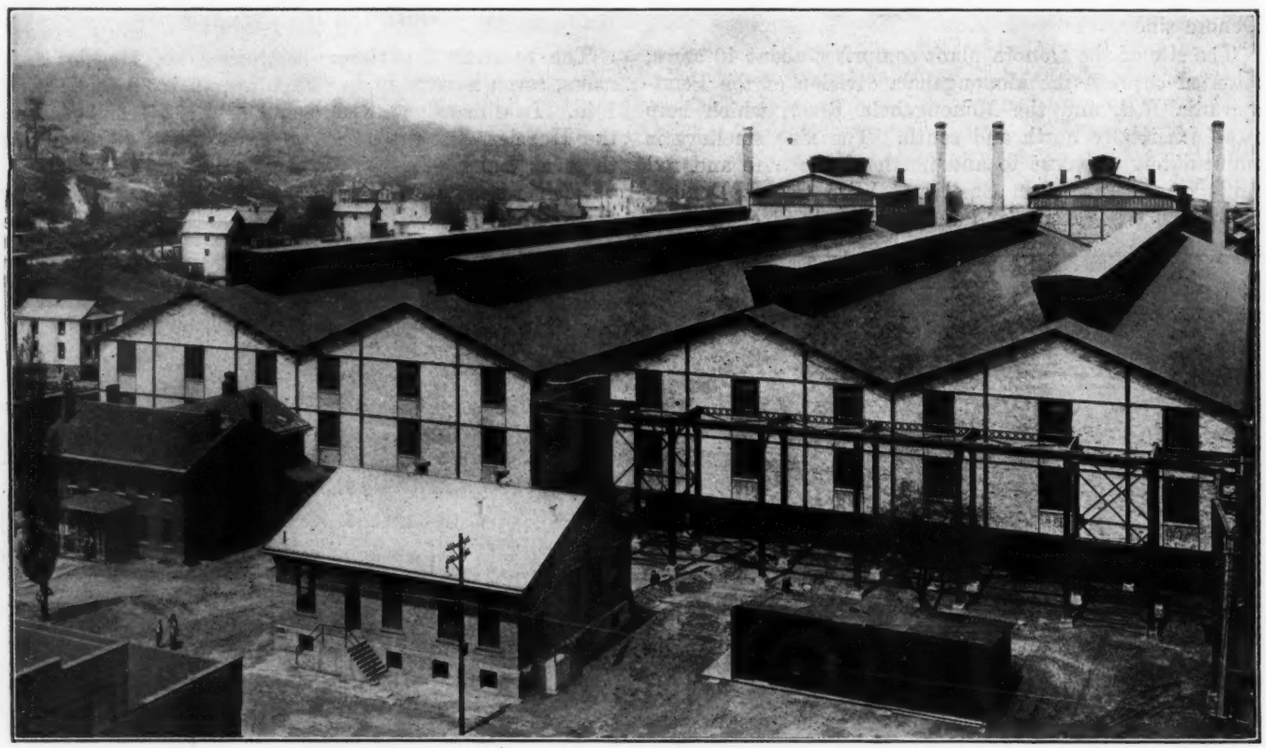
The roasting department comprises six Hegeler furnaces, seven hearths high. Each hearth is 80 ft. by 6 ft. 1 in. In dimensions, design and details of construction, the Hegeler furnaces at Donora are about the same as those at Langeloth.

Each roasting furnace at Donora is fired with gas delivered by a Hughes 10-ft. mechanical producer. The coal consumption is about 11 tons per 24 hr. The combustion gases on their way to the chimney pass through a U-pipe stove, whereby they are cooled down to about 200° C. at the foot of the chimney. The air for secondary combustion passes through the pipe of the stove in the opposite direction and is heated to about 400° C. The air is supplied by a Sirocco fan. In practice in the roasting of Australian ore, however, it has been found that the Hegeler furnace had a tendency to run too hot, and lately the furnace gases have been by-passed directly to the chimney, the arrangement of the flues, etc., in connection with the stove easily permitting that to be done.

In the roasting of Australian concentrates the Hegeler furnaces at first did about 50 tons each per 24 hr., but

there has been a good deal of trouble from sintering of the ore, and the furnaces are now[1] down to about 40 tons. The loss of weight in roasting is about one-sixth. The sulphur is reduced to 1½ to 2%. The coal consumption is about 11 tons per 24 hr., being about the same whether 40 or 50 tons are being roasted. The furnace is operated in two shifts per 24 hr., which requires four men per shift. Two extra men per shift are required to bar sintered ore off the hearth. A temperature of 1,000° C. is registered on the second hearth. Raking is done every three-fourths hour.

The furnace gases contain about 4½% of sulphur dioxide. They are raised to about 8% content by the burning of brimstone in the dust-catchers, the brimstone being simply introduced thereinto, taking fire from the heat of the gas and burning with its excess of oxygen.



NORTH VIEW FROM MIXER BUILDING, SHOWING ACID DEPARTMENT

About 10,000 to 15,000 lb. of brimstone per furnace is thus introduced daily.

The roasting gas reaches the Glover tower at a temperature of about 450° C. The fire gases reached the chimney with a temperature of about 200° C. when the stoves were in use, the air of secondary combustion being preheated to about 400° C., but as mentioned, the stoves had to be bypassed, the tendency of the furnaces being to run too hot. Each roasting furnace has its own chimney, which is of concrete construction, 110 ft. high and 5 ft. inside diameter at the top. Each roasting unit is complete in itself, furnace in its own house, with gas producer, air stove, fan, dust-catcher and chimney immediately adjacent. Each pair of roasting units serves one sulphuric-acid unit.

The roasted ore drops into a tunnel running under the row of furnaces in transverse direction. In this tunnel it is received in Neeland buckets, which are used throughout the plant for the transportation of material and are handled by the overhead telpherage system. The roaster gas on leaving the furnace passes through a centrifugal dust-catcher, 30 ft. high and 20 ft. in diameter. In roasting Broken Hill sulphides of about 20-mesh size, the dust here collected is about 2% of the ore roasted.

Sulphuric-Acid Department

The sulphuric-acid department consists of three units, each comprising a tower building 71x150 ft. and a chamber building 138x440 ft. Each tower building contains 8 towers—2 Glovers and 6 Gay-Lussacs—and 20 lead chambers, this plant being for two roasting furnaces. The gas from each roasting furnace having passed through its set of Glover towers, each tower being 14x14x40 ft., goes through a train of 10 lead chambers the aggregate volume of which is 360,000 cu.ft.

The construction of the sulphuric-acid department at Donora is very similar to that at Langeloth. The buildings are of steel with panel walls of hollow brick. This is an excellent and pleasing method of construction. From one of the accompanying engravings the reader can get a good idea of it. The framing for the acid chambers is, of course, of timber. The walks are of timber, and under them, to save men who might accidentally fall over, are the excellent nettings of heavy wire, that were so commendable a feature at Langeloth.

The Mixing Department

The roasted ore is taken from the roasting furnaces by overhead trolley and Neeland buckets to the storage bins of the mixing house. In other bins of the same house is stored anthracite fines for reduction material. These bins are vast concrete-lined pits like all the other

[1]May, 1916.

main storage bins of this plant. Overhead the house is spanned by a traveling crane.

The reclamation of ore and coal from the main bins is done by a clamshell bucket handled by the crane. This transfers the ore and coal into overhead steel bins at one end of the house. From these bins the charge is drawn as required into a weighing car and from the latter it is chuted into the mixers, whereof there are two. The mixers are hexagonal drums, the heads of which are slanted, so that a cross-section through the shaft is of rhomboidal shape. In the turning of the drum the charge receives therefore not only a peripheral mixing, but also a lateral shifting.

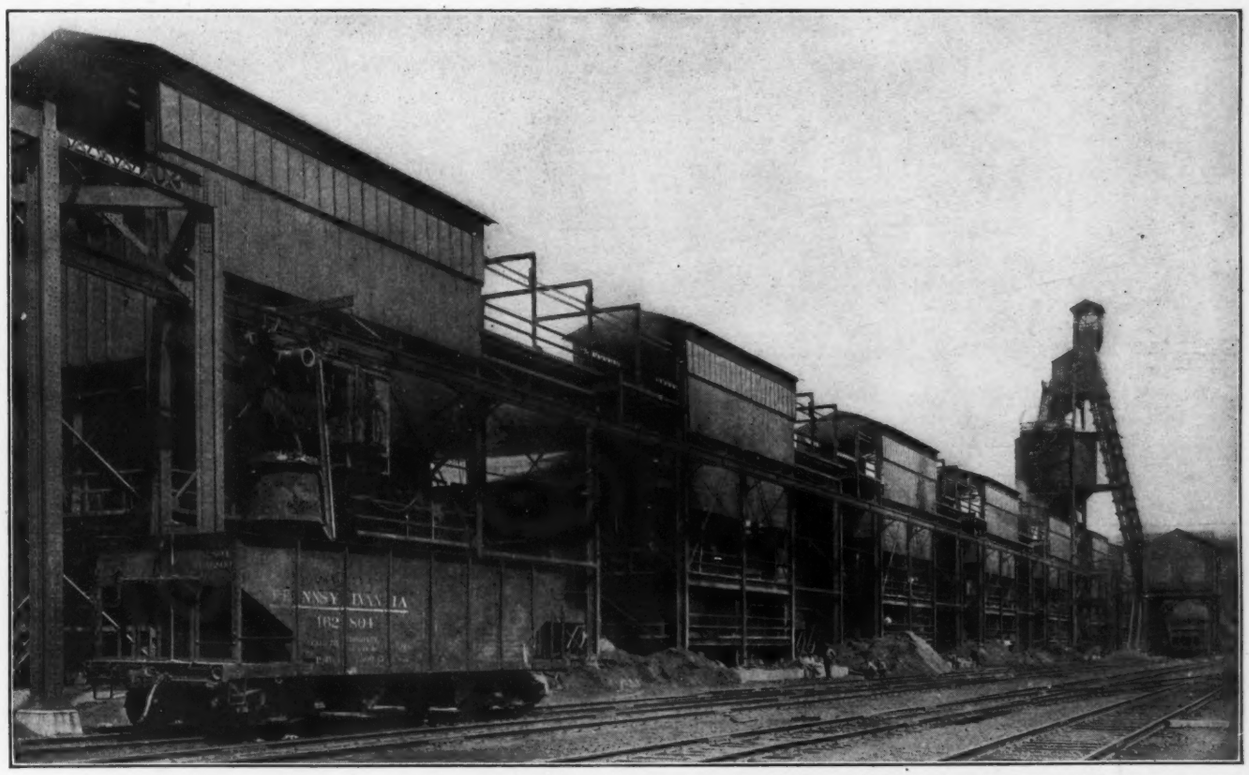
At the time of my visit some trouble was being experienced in handling sintered lumps coming from the roasting furnaces. Probably it will be necessary to introduce some mechanical means of pulverizing these, which may have been done already.

From mixing drums the charge is received in the large cars to go to the distilling furnaces. These are pulled up the incline by a winch and upon reaching the level track on the ground surface are pushed down by the ends of the furnaces, each car being shifted to the furnace tracks as required, according to the usual system in American works where the furnaces are arranged side by side.

The Distillery

The distillation department comprises 10 Hegeler furnaces, each of 912 retorts, 456 per side, arranged in six rows. Longitudinally the furnace is divided into 19 sections per side, each section comprising 24 retorts. The furnaces are set in parallel, 95 ft. apart center to center. Each furnace is covered by its own house, which is 70 ft. wide, of steel construction, roofed and sided with asbestos-coated, corrugated sheet steel. The spaces between the houses are also roofed over.

The distillation furnaces are similar to those at Langeloth, Penn. The combustion chamber is roofed with a flat arch, self supporting from the side walls and independent of the middle wall, the slope of the arch on each side being parallel to the slope of the retorts. The retorts are of the standard cylindrical shape, 8 in. inside diameter and 52 in. long. The furnaces are very heavily ironed. The buckstaves are connected by tie-rods through springs, thus allowing for expansion. The buckstaves footings are fitted with ball-and-socket joints, permitting free movement in any direction. A new feature of the Donora furnaces is the air flues that go under the floor of the combustion chamber, the purpose of which is to afford preheated air to the first section of the furnace. The Donora furnaces are hooded with counterbalanced sheet-iron shields, and of course are provided with all modern contrivances for discharging the retorts, drawing metal, etc. The ash pockets in front of the furnaces are unusually commodious. They discharge into tunnels running longitudinally under each furnace, whence the residues are removed by means of Neeland buckets.



VIEW ALONG SPELTER FURNACES SHOWING GAS-PRODUCER BUILDINGS AND COAL HOIST

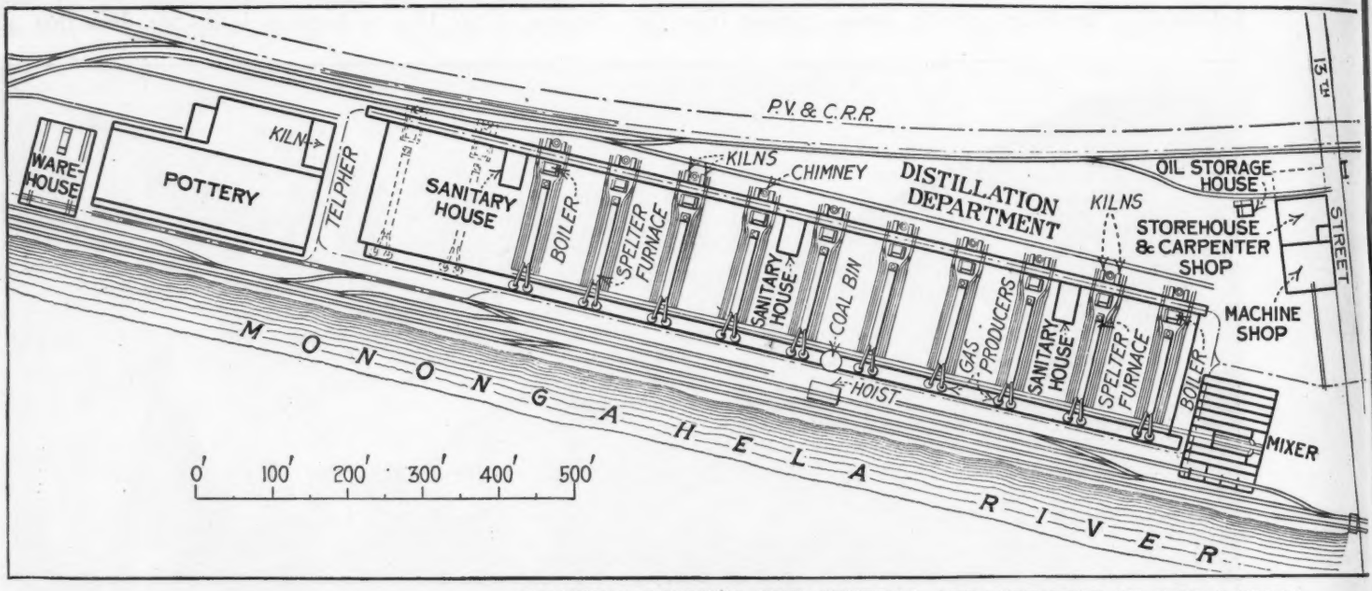
Each furnace is provided with two 10-ft. Hughes gas producers, steam-blown. The gas from the producers enters the furnace at 500° C., there being but little loss of the heat of primary combustion owing to the close proximity of the producers to the furnace. The air for secondary combustion is furnished by a No. 6 Sirocco fan, driven by a 50-hp. motor. At the far end of the furnace the products of combustion pass through a 588-hp. Rust boiler and thence to a chimney of concrete construction.

125 ft. high and 5½ ft. inside diameter, which is lined with firebrick to a height of 30 ft. above the bottom. At the foot of this chimney are the retort-tempering furnaces, one on each side, directly connected with the chimney.

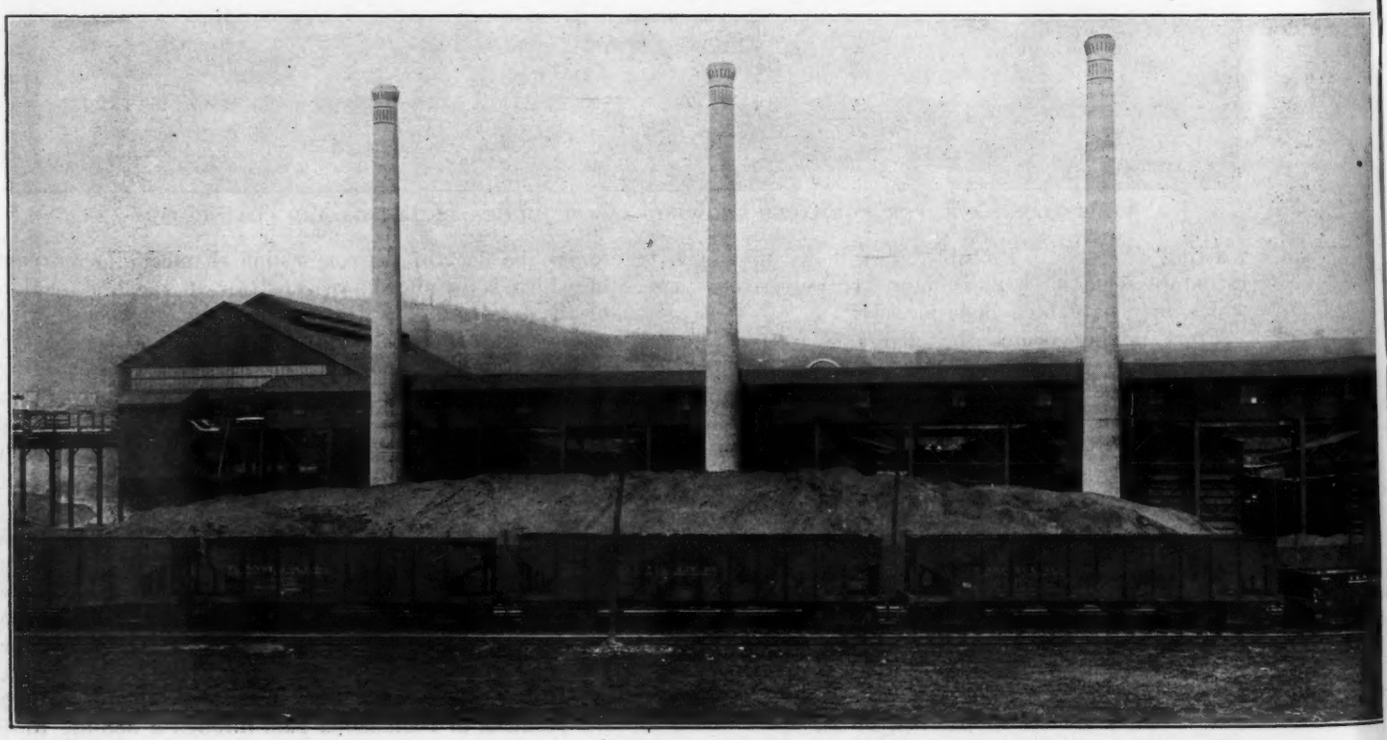
The Pottery

The retort- and condenser-making equipment is contained in a brick and steel building 121x289 ft., with an addition 66x128 ft. in which the machinery is concentrated. The main part of the building is devoted to the drying rooms, of which there are 28, whereof 25 are for retorts, each holding 900 retorts, and 3 are for condensers. These rooms are heated by steam piping under their grated floors. The moist air is led away through galvanized-iron ducts passing through the roof. The control of the ventilation is much better in this pottery than it is in the ordinary zinc-smelting pottery of the United States.

In the retort- and condenser-manufacturing department of the Donora pottery, the arrangements is in duplicate; that is, there are two independent sets of machines. The machines are of the standard type. There are two dry pans and two wet pans of the American Clay Working Machinery Co., of Bucyrus, Ohia, two Wettengel pug-mills, two Wettengel hydraulic retort presses, and two Garrison & Whipple pug-mills and condenser machines.



DRAWING SHOWING THE GENERAL ARRANGEMENT OF THE DONORA

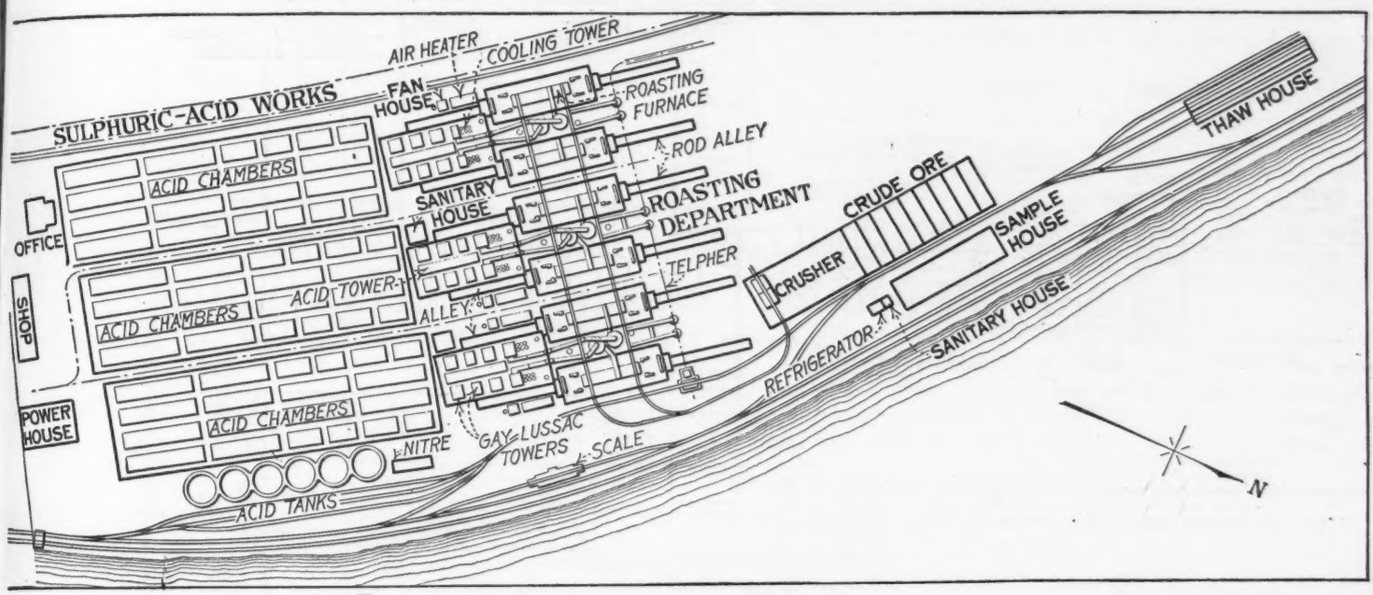


PANORAMIC VIEW OF THE DISTILLING DEPARTMENT.

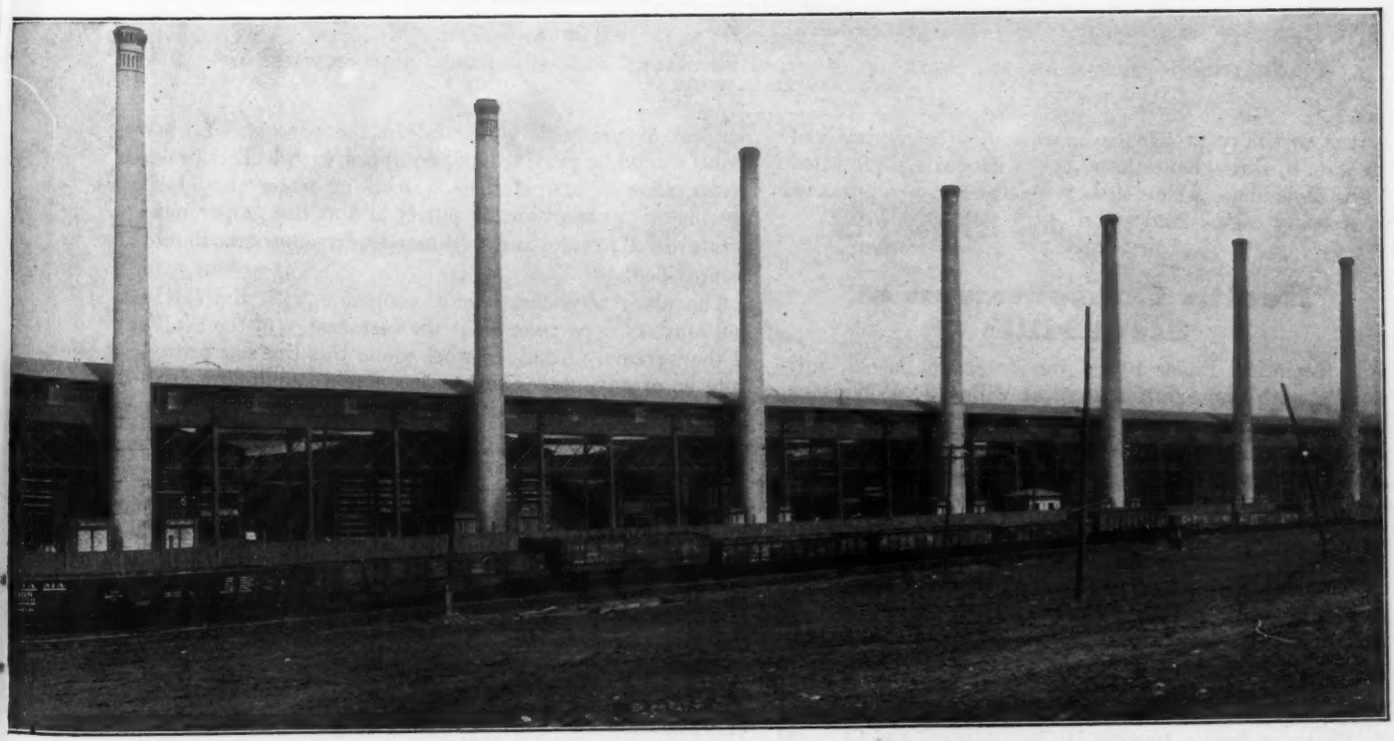
From the dry pans, in which the clay is thoroughly ground, it is conveyed mechanically to overhead bins from which the several clays used in the batches are drawn in proper proportions for mixing on the mixing platform. The mixed clay is thoroughly incorporated in wet pans, the product of which is conveyed to the rotting rooms for seasoning. The seasoned clay is pugged and molded into condensers in the usual way. The capacity of the Donora pottery is about 1,000 retorts and 300 condensers every 24 hr.

The power plant is comprised in a brick and steel building 57x80 ft. The equipment consists of feed pumps, air compressors, rotary converters, transformers, switchboards, etc. The Donora zinc smeltery being operated in connection with the Donora steel plant, coöperation is possible with respect to power, coal supply, etc., that would not be in an isolated plant. The electric current for runing the zinc smeltery is received from the power house at the openhearth steel works. The steam generated in the waste-heat boilers connected with the zinc-distilling furnaces is piped 3,000 ft. back to the power house of the steel works.

The coal for the zinc smeltery is raised from Monongahela River boats by the coal hoist at the openhearth steel works, whence it is transported to the smeltery in steel, hopper-bottom cars. These cars deliver by skip hoist to an overhead bin, the position of which is shown on the accompanying plan, from which it is distributed to



ZINC-SMELTING WORKS OF THE AMERICAN STEEL AND WIRE CO.



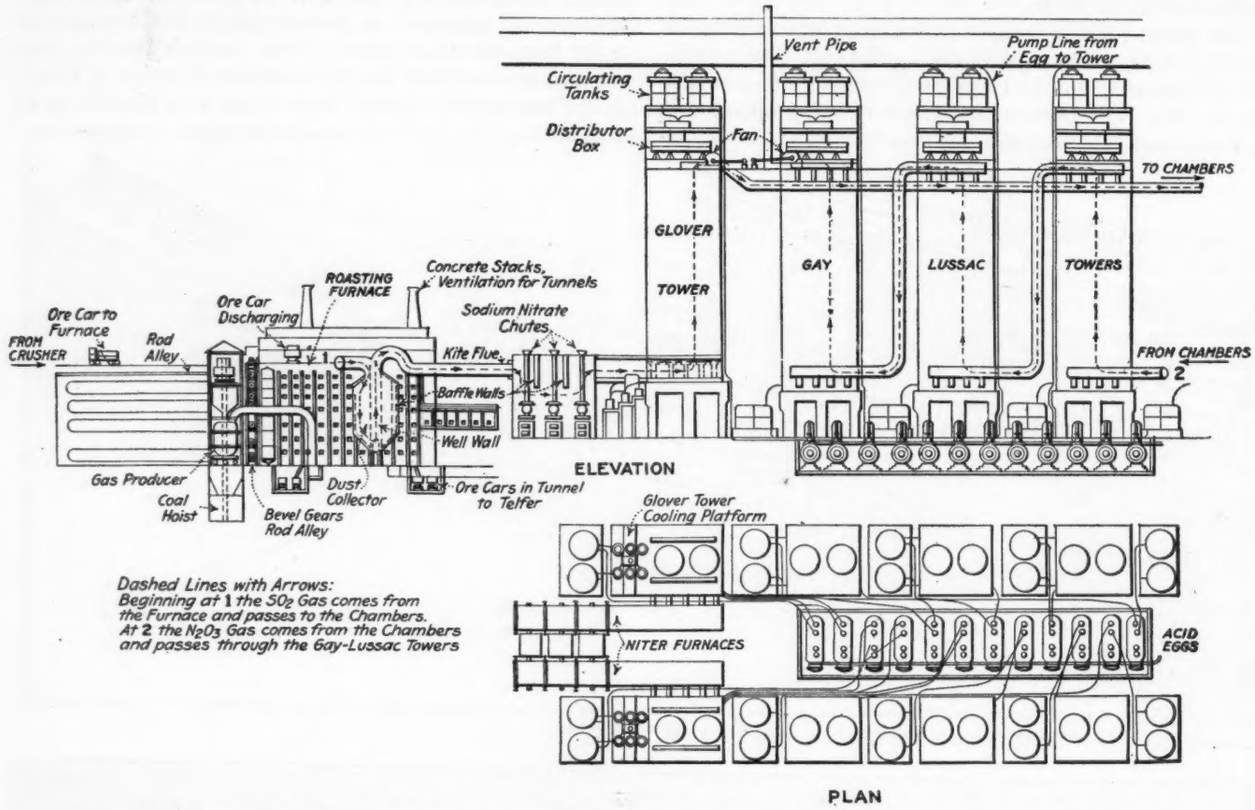
CHIMNEY END, AT THE DONORA ZINC-SMELTING WORKS

the gas-producer bunkers by a larry. The main bin contains two days' supply. At the main coal hoist of the steel works, however, a much larger supply is kept in reserve.

In the construction of the Donora plant careful attention was paid to the installation of all proper sanitary and safety devices. There are bubbling drinking fountains, lavatories, shower baths and steel lockers. The unusual and commendable arrangements of the houses in the distillery proper have previously been remarked. Machinery throughout the works is adequately protected. Vertical ladders, where such are necessary, are protected by a safety cage. And so on.

In the original plant construction arrangements should be made for the best possible illumination—natural if possible, or if artificial is used, the requirements of the different parts of the plant should be studied and an understanding gained of the effects of diffused lighting and concentrated lighting and the design governed accordingly. Care should be taken in floor construction to permit cleaning where necessary. Ventilation should be provided both in regard to the renewal of air and the removal of products incidental to the process. Locker rooms should be provided and equipped with lockers, wash basins, showers and latrines. Drinking water should be provided of unquestionable purity and at the proper temperature. Uptodate and well-managed restaurants should be provided.

The plant physician should coöperate with the safety and sanitary departments for the furtherance of the health of the workers. Result of work along this line has proved it to be of advantage from an economic standpoint, irrespective of its humanitarian aspects.



DIAGRAMMATIC ELEVATION AND PLAN OF ROASTING FURNACES AND SULPHURIC-ACID TOWERS OF DONORA ZINC WORKS*

Health Conservation at Steel Mills

In Technical Paper 102 of the Bureau of Mines, entitled "Health Conservation at Steel Mills," J. A. Watkins, the author, has carried the "safety first" idea a step farther to include "health first." Data in his possession show that approximately nine days a year are lost by the average industrial worker owing to illness. To reduce this in large industrial plants there should be medical supervision over all employees. This should include (1) relief of those injured at work, (2) examination of prospective employees, (3) medical supervision of entire force to detect disease or abnormal conditions among the workers, (4) sanitary supervision of the plant, (5) education in personal hygiene for employees and their families.

*Redrawn from a drawing in "Metallurgical and Chemical Engineering," by courtesy of that paper.

The Mount Bischoff Tin Mining Co., at Launceston, Tasmania, shows an earning of $35,372 for the first half of 1916. Interest to the amount of $1,168 brings the total credit to $36,540. Dividends to the extent of $21,870 were paid. A total of 49,632 tons of ore were produced from the various surface faces. No underground work was carried on during the half-year. The total ore reserves consist of 1,616,000 tons—the majority of which is in surface faces. Plans are under consideration for the addition of 20 stamps in the mill and experiments in concentration on glass-topped tables, which is expected to be of benefit in the treatment of the slimes. The working costs for the period were $1.91 per ton, 1,538.8 tons of concentrate were smelted yielding 1,059.75 tons of tin. The product had a purity of 99.89%.

Van Buren Smelting Plant

By F. W. Bocking*

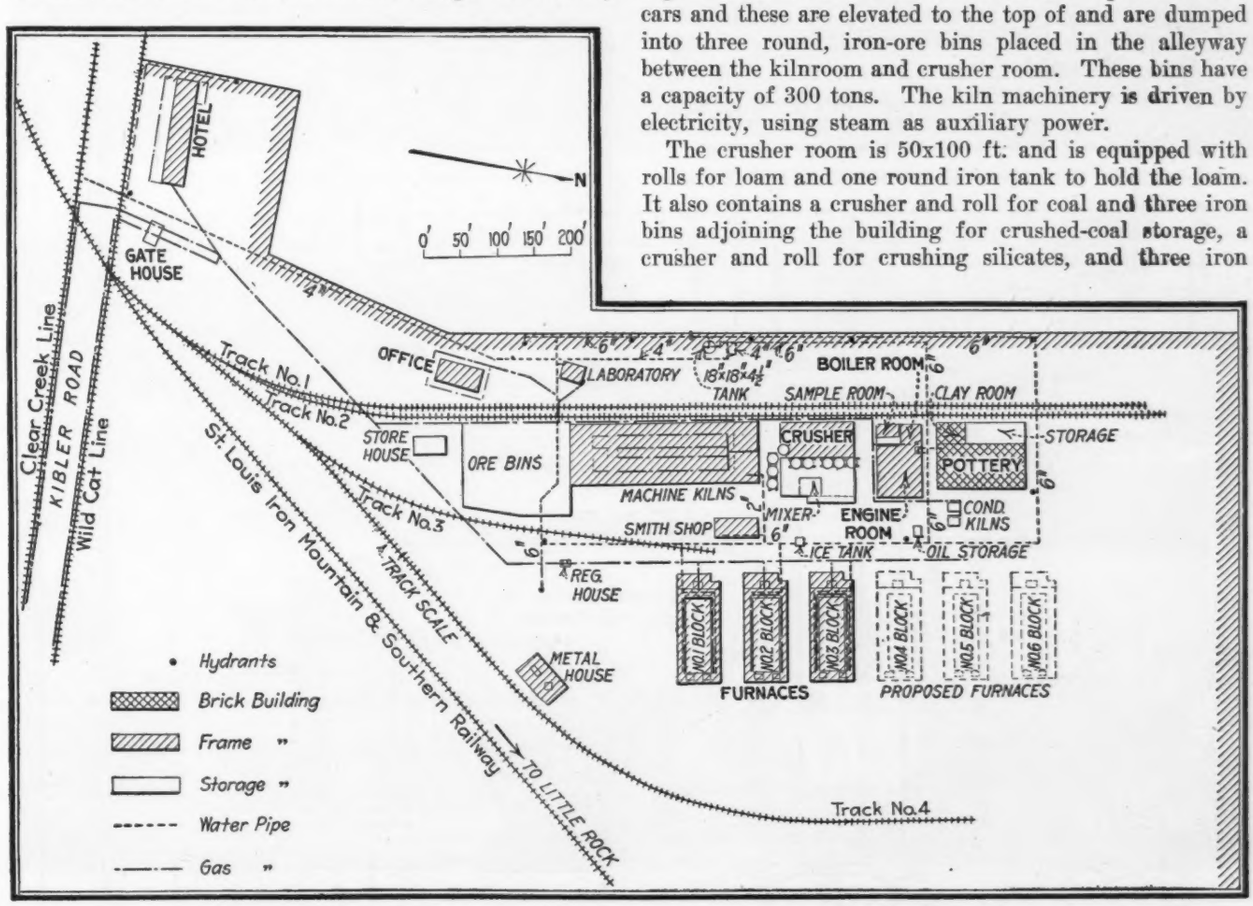
SYNOPSIS—The Van Buren plant is exceptionally well provided with railway facilities and is in good position to handle its tonnage of zinc ores. Equipment includes kilns, crushers, a pottery and the requisite furnaces and other necessities of a well-equipped zinc-smelting plant.

The Van Buren smelting plant of the Arkansas Zinc and Smelting Corporation is situated about a mile east of Van Buren, directly between that city and the Kibler gas field. It is between the St. Louis, Iron Mountain & Southern Ry. and the St. Louis & San Francisco Ry., but at present is connected only with the former. Tracks No. 1 and No. 2 are connected with a switch so as to be able to handle cars to and from the silicate storage and crusher, pottery and coal crushers without interfering with the placing of cars or unloading sulphide ore on track No. 2 and vice versa. Tracks No. 2 and No. 3 are used for unloading sulphides into large ore bins. The space between tracks No. 3 and No. 4 is used for coal and coke storage. Track No. 4 is used also for weighing ore, loading spelter and loading out waste residues and residues carrying precious metals. Besides the storage room for coal between tracks No. 3 and No. 4, there is ample storage for silicate ore and coal opposite the pottery, engine room and crusher building.

The sulphide-ore bins are between tracks No. 2 and No. 3. The outside walls and floor are of concrete, and the partitions are of wood. The floor is lower than the tracks, the outside walls coming just high enough to be level with a box-car door, which makes it possible to unload directly from the cars, dumping into the bins. The 20 bins have a capacity of about 4,000 tons and adjoin the kilnroom.

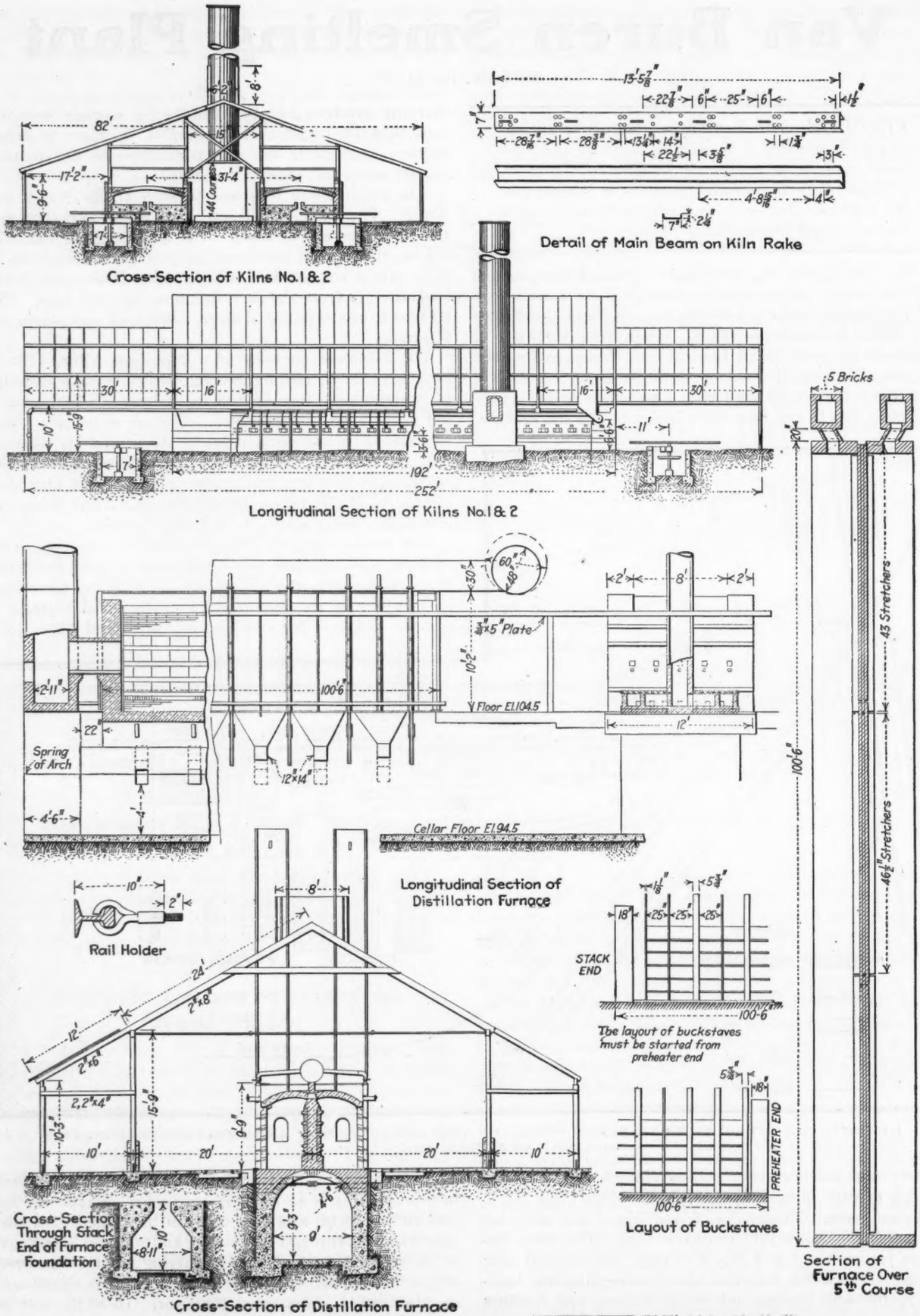
The kilnroom contains two Ropp-type kilns, 175 ft. long with 20-ft. cooling hearths, which have a capacity of from 20 to 25 tons each of roasted ore per day, according to the class of ore roasted. The ore drops into tramcars and these are elevated to the top of and are dumped into three round, iron-ore bins placed in the alleyway between the kilnroom and crusher room. These bins have a capacity of 300 tons. The kiln machinery is driven by electricity, using steam as auxiliary power.

The crusher room is 50x100 ft. and is equipped with rolls for loam and one round iron tank to hold the loam. It also contains a crusher and roll for coal and three iron bins adjoining the building for crushed-coal storage, a crusher and roll for crushing silicates, and three iron bins adjoining the building for crushed-ore storage. Next to this building is an extra storage room, 50x100 ft., for coal and ore, with a mixing room in the center. All silicate ore is put through the crusher and roll and is sampled by an automatic sampler. The mixing room is equipped with a No. 64 Ransome mixer. The charge is mixed and elevated into a short screw conveyor. Here the mix is wet. After the requisite mixing, the conveyor deposits it into the charge cars.



GENERAL LAYOUT OF THE VAN BUREN WORKS OF THE ARKANSAS ZINC AND SMELTING CORPORATION, VAN BUREN, ARK.

*General manager, Arkansas Zinc and Smelting Corporation, Van Buren, Ark.

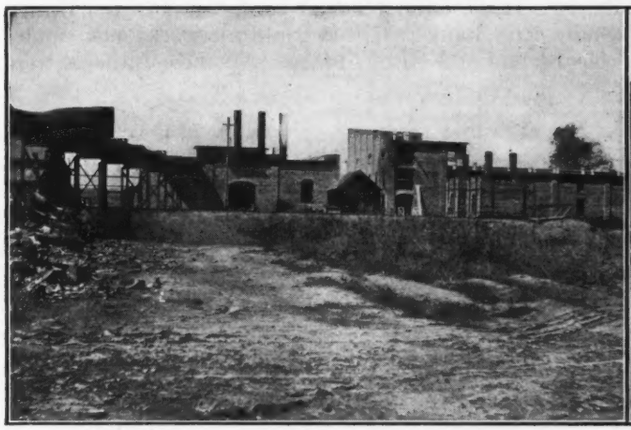

Cross-Section of Kilns No.1 & 2
Detail of Main Beam on Kiln Rake
Longitudinal Section of Kilns No.1 & 2
Rail Holder
Longitudinal Section of Distillation Furnace
Layout of Buckstaves
Cross-Section Through Stack End of Furnace Foundation
Cross-Section of Distillation Furnace
Section of Furnace Over 5th Course
Floor El.104.5
Cellar Floor El.94.5
Spring of Arch
STACK END
PREHEATER END
The layout of buckstaves must be started from preheater end
43 Stretchers
46½" Stretchers
5 Bricks

GENERAL DRAWINGS AND DETAILS OF THE VAN BUREN KILNS AND DISTILLATION FURNACES

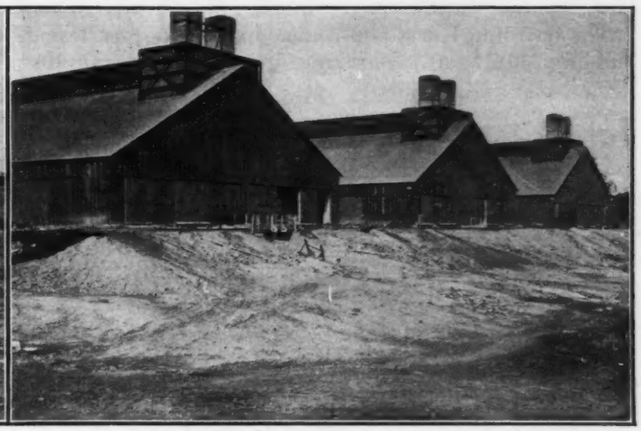
The engine room is in a brick building 60x100 ft. Its equipment includes three 125-hp. boilers, one 200-hp. corliss engine and one 125-hp. generator. In addition to this there is a second unit for emergency purposes, consisting of one 125-hp. corliss engine and one 100-hp. generator. A lineshaft runs through the engine room, extending through the crusher room and pottery and transmitting all the power for the pottery and crusher room. The 60-in. blowers are connected with two 50-hp. engines. Only one is required, however, and the other is held for emergency.

At the end of each block and in the furnace building is a retort kiln. To one side and at the end of the building is a shower bath in each block. The furnaces are so placed as to provide for the construction of four or five more blocks without disturbing any other part of the plant, as the capacity of the ore bins, crusher room, power house and pottery are such as to supply an eight-block plant.

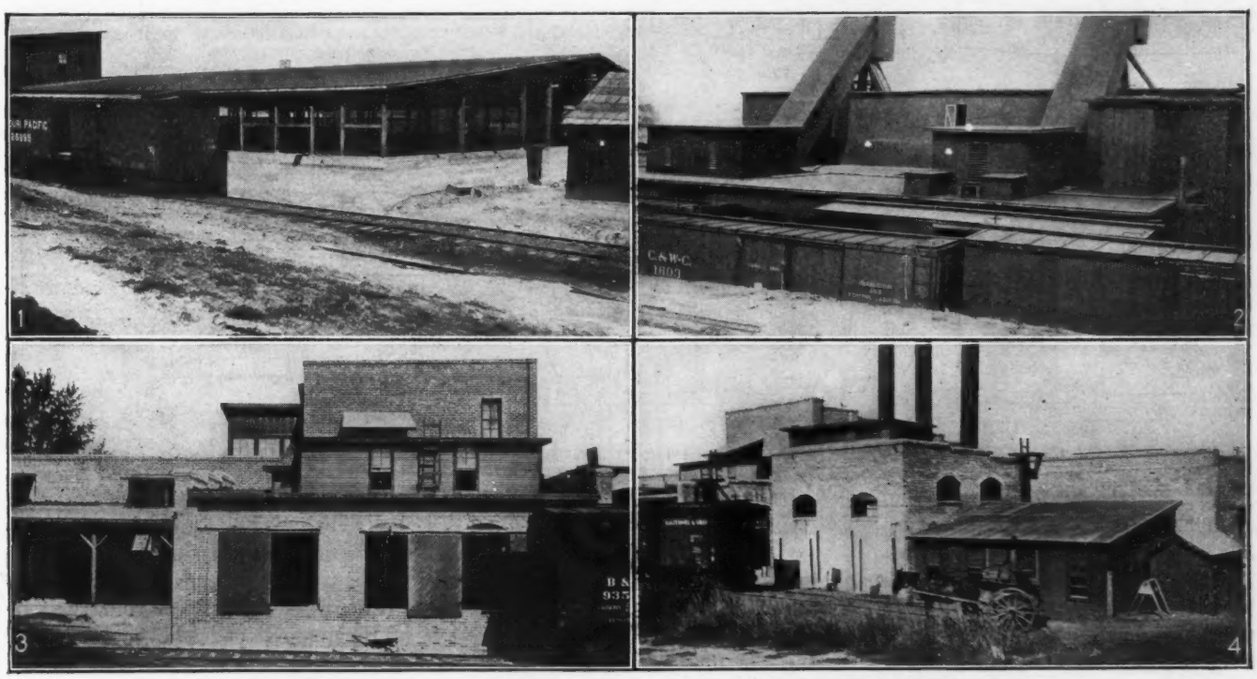
A remelting pot of 25 tons capacity is now being constructed. This is not being built exclusively for settling



EAST VIEW OF POTTERY AND ENGINE ROOM



A VIEW OF THE EAST END OF THE FURNACES



SOME VIEWS OF THE VAN BUREN SMELTING WORKS, VAN BUREN, ARK.
1—The ore bins. 2—The crushing department. 3—The pottery. 4—The engine and boiler rooms

The pottery is contained in a two-story brick building 90x120 ft., equipped with the usual crushers and rolls for crushing clay and dobies, and pug mill and tile machine for making retorts, with a ball mill and condenser machine of the Garrison & Whipple type. Adjoining the pottery are two large condenser kilns.

There are now completed three blocks of 800 retorts each, which are five rows high. Underneath the foundations and extending over the entire cellar floor is a 6-in. concrete slab, and the walls of the cellar are concrete also.

out lead or iron, but more with the view to making the shipment of a car more uniform throughout, thus avoiding the danger of the purchaser accidentally using in his sample any greater proportion of one draw of metal than another.

The plant is connected directly with the water mains of Van Buren, which maintains a pressure of 70 lb. In addition to this there is a 30,000-gal. tank, which is kept full by a float valve connected with the water mains. Leading from this main is a complete circuit of 6-in. pipe

around the plant without any dead-ends. This line has, placed at the most important points, hydrant and hose connections—eleven hydrants in all. Should a fire occur at any time, the 500-gal. fire pump is started. A separate suction line connected with the pump and the 30,000-gal. tank make it possible to draw from both tank and city water mains if desired or, by closing a valve, to draw only from the city water mains and hold the 30,000-gal. tank in reserve. Each building is equipped with hydrants with linen hose attached, using a total of 1,000 ft. of hose.

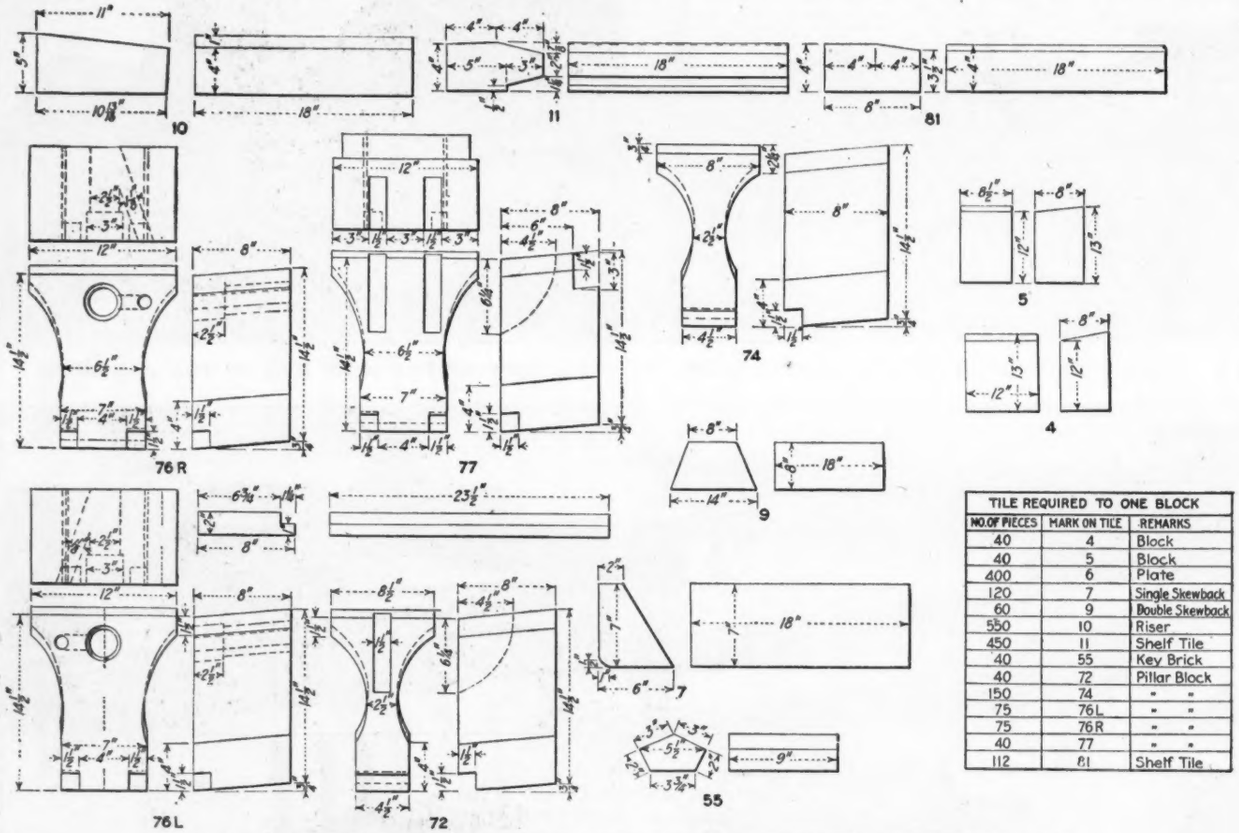
The boarding house is a commodious, two-story frame building, 30x124 ft., consisting of a sleeping porch 10x124 ft., 27 rooms, 3 bathrooms and an extra washroom, a kitchen 20x30 ft., a dining room 30x30 ft., and a lobby 30x30 ft.

It was the intention of the company to build here so that later there would be no difficulties encountered due to poor construction in any way, and accordingly extraordinary precautions were taken in constructing the foundations, using over 175 carloads of cement, gravel and sand in the foundations and concrete work alone.

The Premelting of Ferroalloys is discussed in "Iron and Coal Trades Review," Aug. 25, 1916, in connection with a device for the purpose invented and patented by Wheeler and Blair, in England. A melting compartment is provided as an extension to the rear wall of the furnace, and in this compartment the alloys are designed to be melted, utilizing the heat of the furnace. The compartment is preferably placed near the top hole of the furnace, and the melting chamber is open to its interior. A melting hearth is provided for the chamber, and also a tap hole. Entrance to the chamber is through a back opening that can be closed by a sliding door. The alloys to be melted are charged through this door and are then subjected to the heat of the furnace.

Late Blast-Furnace Designs

The general lines of several blast furnaces of recent design are shown in the accompanying illustrations. They represent three important examples of modern blast-furnace equipment: (1) A large black-copper furnace used at the Katanga copper field in the Belgian Congo; (2) a copper-matting furnace with plunger-feed arrangement, at the Anyox, B. C., plant of the Granby Consolidated Mining, Smelting and Power Co.; and (3) a lead furnace at the latest plant to be designed in the United States, the Bunker Hill & Sullivan works now under construction at Kellogg, Idaho. All these furnaces were fabricated by the Traylor Engineering and Manufacturing Co., of Allentown, Penn., which has kindly supplied the general drawings from which the illustrations have been made, and the information contained in following brief notes on the general features of the furnace construction:

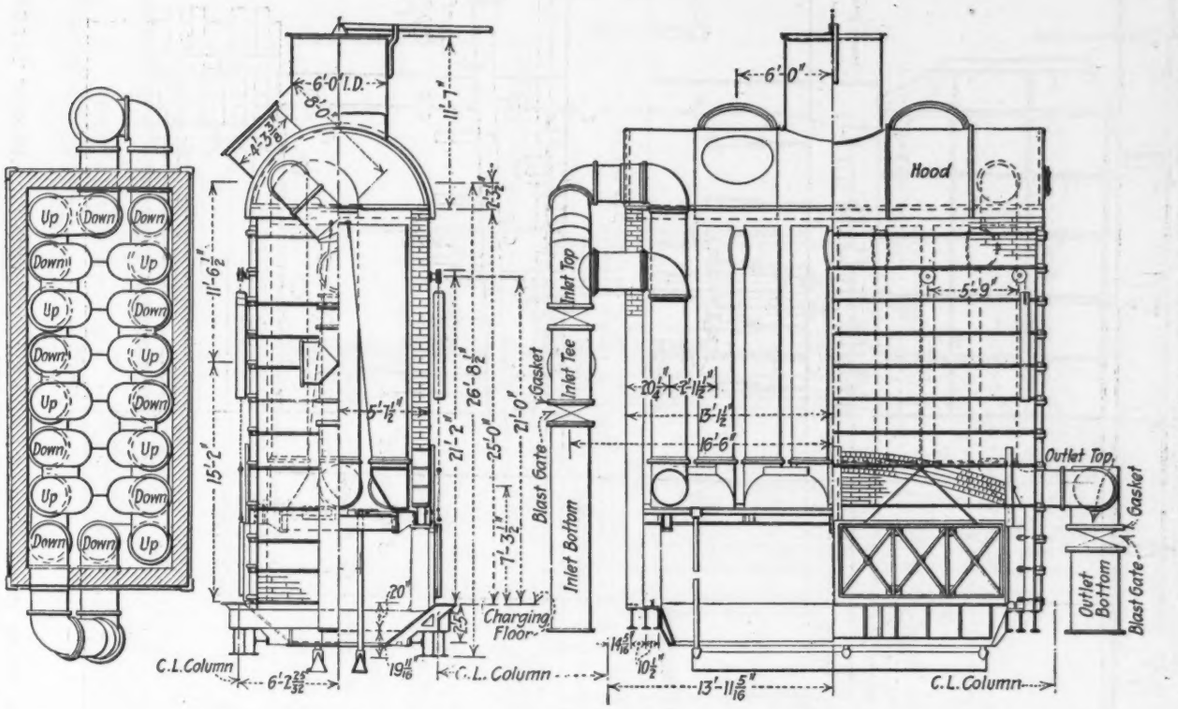


TILE REQUIRED TO ONE BLOCK		
NO. OF PIECES	MARK ON TILE	REMARKS
40	4	Block
40	5	Block
400	6	Plate
120	7	Single Skewback
60	9	Double Skewback
550	10	Riser
450	11	Shelf Tile
40	55	Key Brick
40	72	Pillar Block
150	74	" "
75	76L	" "
75	76R	" "
40	77	" "
112	81	Shelf Tile

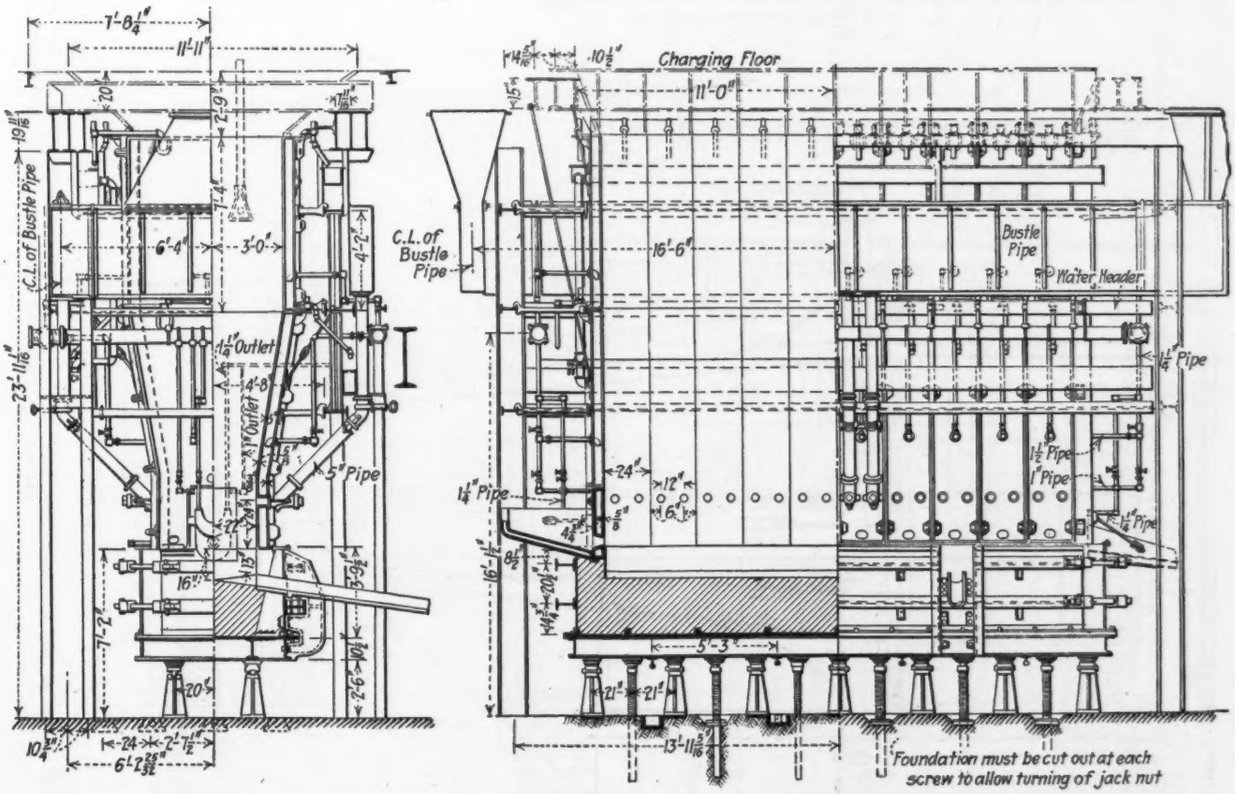
DETAILS OF THE BRICK SHAPES FOR DISTILLATION FURNACES, VAN BUREN, ARK.

The illustrations on the opposite page show a 44x240-in. black-copper furnace, four of which were sent to the Union Minière du Haut Katanga, at Lubumbashi, near Elisabethville, Belgian Congo. This equipment is of special interest as the operation in the Belgian Congo is one of the few places in the world today where an important output of black copper is being made. The Katanga company is probably turning out the largest production ever made by this method in a single plant, and the furnaces themselves are undoubtedly the largest ever used for smelting to black copper.

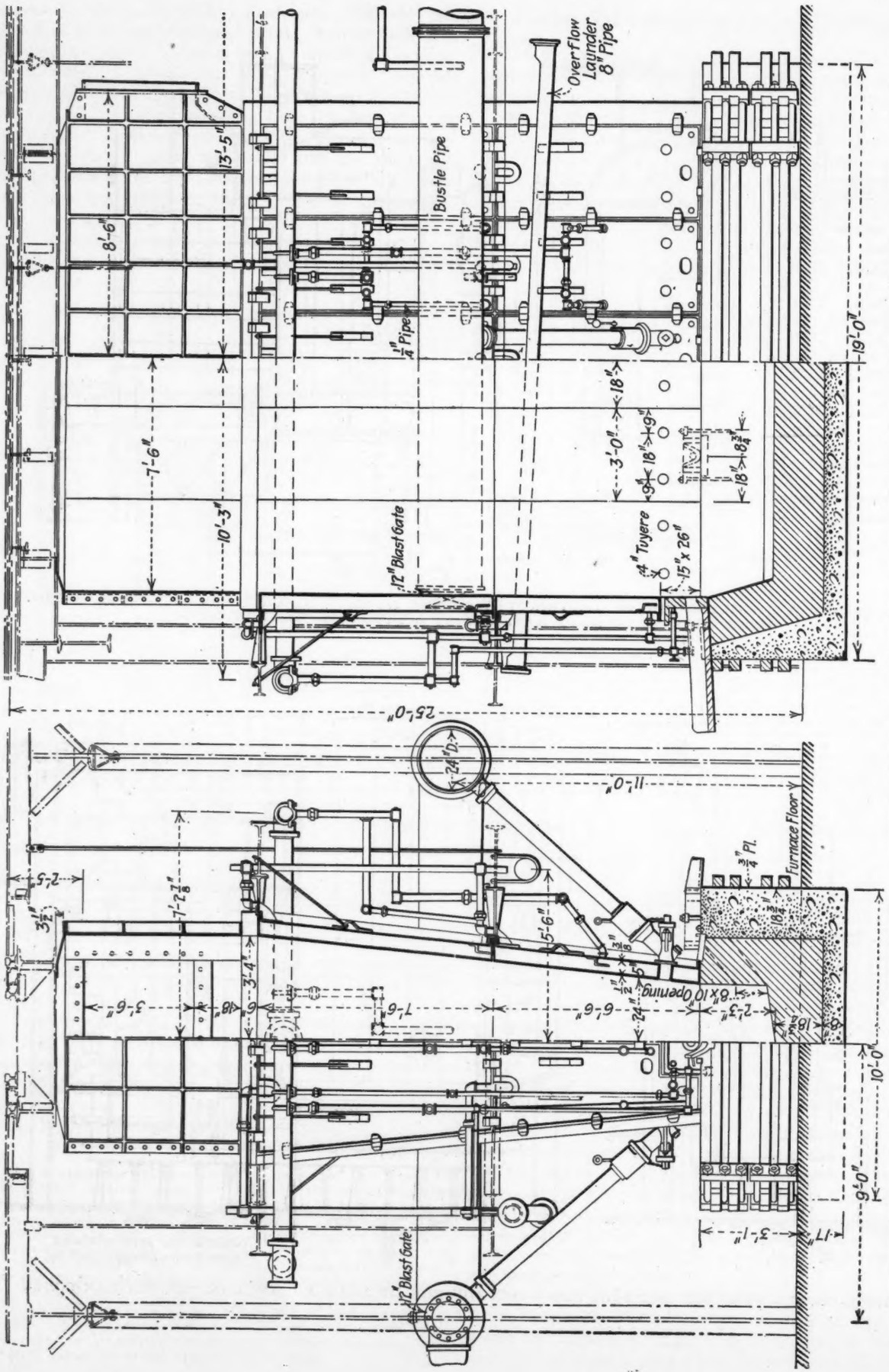
The Katanga furnace has two tiers of jackets, the lower ones being of the knee type 10 ft. high and 24 in. wide; the furnace is 44 in. wide at the tuyere line; the bosh begins about a foot above the center of the tuyeres



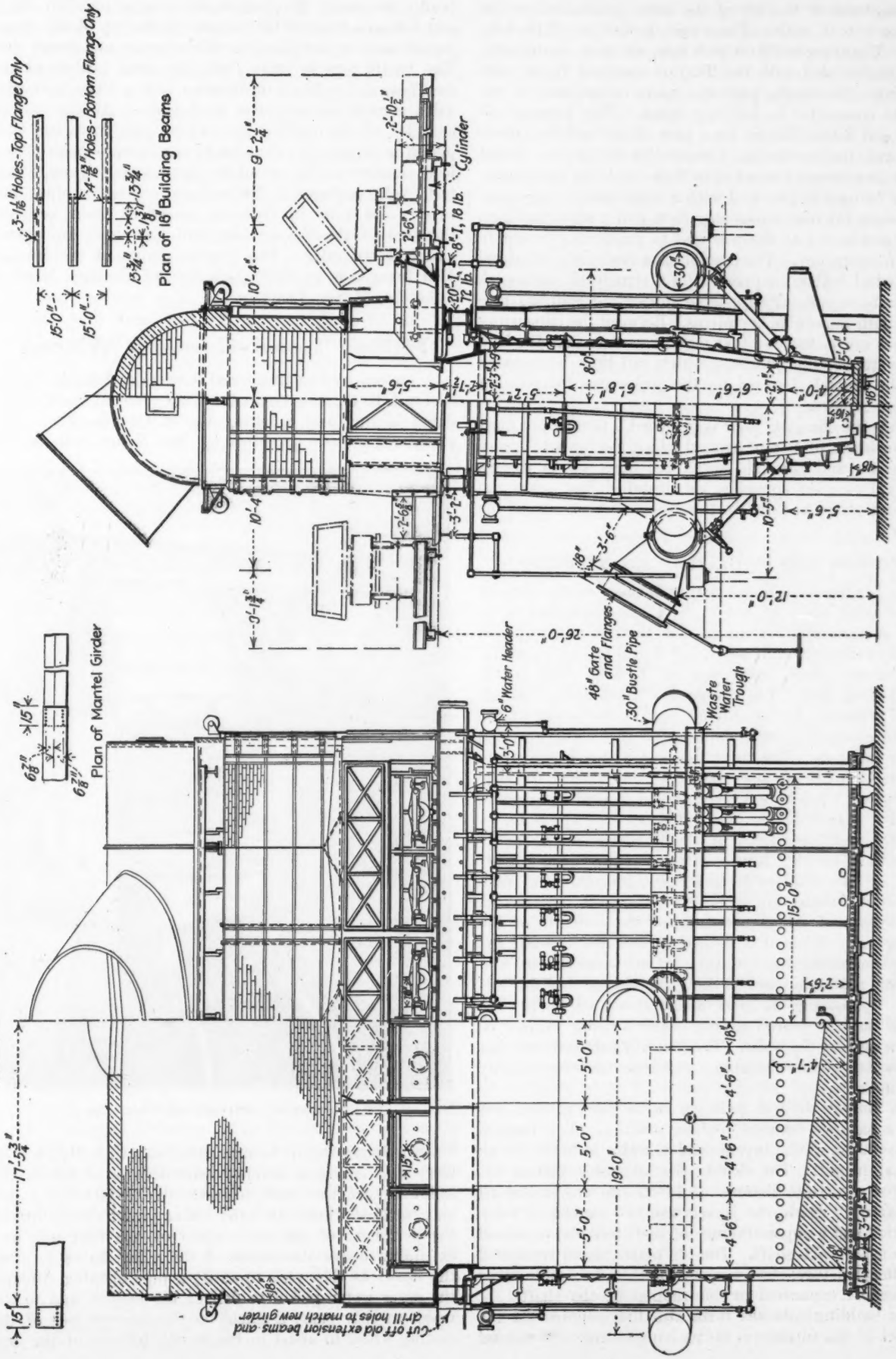
GIROUX HOT TOP, BUILT IN THE SUPERSTRUCTURE OF THE 44x240-IN. BLACK-COPPER FURNACE OF THE UNION MINIERE DU HAUT KATANGA, AT LUBUMBASHI, BELGIAN CONGO



BLACK-COPPER FURNACE, 44x240-IN., FOR UNION MINIERE DU HAUT KATANGA IN THE BELGIAN CONGO



BUNKER HILL & SULLIVAN'S 48x180-IN. LEAD BLAST FURNACE, THREE OF WHICH ARE TO BE INSTALLED AT THE NEW SMELTING WORKS NOW UNDER CONSTRUCTION, AFTER PLANS OF BRADLEY, BRUFF & LABARTHE, AT KELLOGG, IDAHO


Plan of 18" Building Beams
Plan of Mantel Girder
Cylinder
6" Water Header
48" Gate and Flanges
30" Bustle Pipe
Waste Water Trough
Cut off old extension beams and drill holes to match new girder

THE 54x360-IN. COPPER-MATTING FURNACE, ARRANGED FOR PLUNGER FEEDING, AT THE ANYOX, B. C., PLANT OF THE GRANBY CONSOLIDATED

and continues to the top of the lower jackets, where the furnace is 6 ft. wide. The upper jackets are 7 ft. 4 in. high. The tuyeres, 20 on each side, are 4 in. in diameter and are provided with the Traylor standard tuyere connections. The bustle pipe was made rectangular in section to economize in building space. The furnace columns and mantel beams are a part of the building structure, and the horizontal I-beams for taking the thrust of the jackets are framed into these building columns.

The furnace is provided with a water-jacket trap spout and breast for continuous slag flow, and a plain cast-iron spout and breast at the rear end to drain the furnace in case of emergency. The crucible has steel-plate sides and a cast-steel bottom, supported on a structural framework that rests on special adjustable supporting columns provided with removable key pieces. Between the supporting columns are jackscrews that may be used to take the load off the supporting columns, which can then be removed and the crucible lowered on the jackscrews for relining or other repairs.

Above the charging floor is provided a Giroux hot-blast top consisting of U-pipe around which the heated furnace gases pass and through which the blast air is drawn. Two water-cooled spreaders are installed just below the charging plates to assist in the proper distribution of the charge.

Plunger Feed on Granby's Anyox Furnace

The 54x360-in. copper-matting furnace of the Granby Consolidated plant at Anyox, B. C., is illustrated on p. 660. A particular feature of this furnace is the special plunger-feeding arrangement, but it also has an unusually deep furnace shaft, being now 24 ft. 6 in. from hearth plate to feed floor. The furnace has three tiers of jackets and is arranged for continuous flow at the center of the side, an emergency drain spout and breast being provided on the rear side. The lower side jackets are boshed from the hearth plate up and extend for a vertical distance of 10½ ft. They have Traylor patent welded tuyeres and standard tuyere connections. The tuyeres are 5 in. in diameter and are spaced at 11-in. centers.

The most striking feature of the Granby furnace, however, is the plunger-feeding arrangement. On each side of the furnace are six of these charging devices into the hoppers of which are dumped the contents of the charge cars. When it is desired to feed the furnace, the valves controlling the hydraulic cylinders are opened and the plow moves forward pushing the charge into the furnace. By moving the plow ahead slowly or rapidly the charge may be placed in the center of the furnace or thrown against the walls. The manufacturers report that the working of this charging arrangement has been highly satisfactory.

The Bunker Hill & Sullivan furnace on p. 661 presents some new features in lead practice. The furnace is 48x-180 in. at the tuyeres and is water-jacketed for an unusual height. The double tier of water jackets extend for a vertical distance of 14 ft. and are boshed all the way up. Above the jackets are two courses of brick on which rest a superstructure of cast-steel plates instead of the usual brick shaft. The top plates are so connected with the structural-steel work of the feed floor as to allow the vertical expansion or contraction of the shaft.

The building columns form also the columns for the support of the furnace so far as is necessary. No mantel beams are used. The jackets are held in place by stays, and I-beams encircle the furnace at the top of the upper jackets and at the junction of the upper and lower tier. The bustle pipe is hung from the main girders of the feed floor and is 24 in. in diameter with a 30-in. butterfly-valve connection with the blast main. At the end of each leg of the bustle pipe a 12-in. gate valve has been placed to permit the expulsion of any furnace gases after a brief shutdown. To control the blast of each tuyere, a butterfly valve is placed in the saddle on the bustle pipe. The tuyeres are 4 in. in diameter spaced at 18-in. centers; they are of the Traylor standard type with automatic-cutoff safety valve. The general design of the Bunker Hill furnace is by Jules Labarthe, of Bradley, Bruff & Labarthe, of San Francisco.

Miller Lead-Casting Wheel

A vertical lead-casting wheel devised by John F. Miller, of Trail, B. C., is in use at the Trail plant of the Consolidated Mining and Smelting Co. of Canada, Ltd. The machine has been patented by Mr. Miller both in the

LEAD-CASTING WHEEL AT TRAIL, B. C.

United States and in foreign countries (U. S. Pat. 1,157,-794) and embraces several constructions of which the following are the chief features: Water-jacketed molds on a vertical wheel; an outer water jacket snugly fitting the periphery of the mold wheel on the feed side and extending above the center of the wheel so as to close the molds as they pass upward; a pipe opening through the outer water jacket to deliver the molten lead to the molds as they pass; a shield on the delivery side of the casting wheel to assist in the gentle delivery of the pigs

to the car or conveyor that may be in use for disposing of the product; a small recess in the mold lips, permitting the air to escape into the next mold and providing a receptacle for an automatic sample of the lead. This small sample ingot is ejected by the slight dropping of the main ingot as it passes a certain point of the protecting shield on the delivery side of the wheel. Lead is delivered to the casting wheel by a centrifugal pump set in the bowl of molten lead that is to be cast. The method of filling the molds ingeniously eliminates the usual trimming of the pigs after casting.

The accompanying illustration shows the Miller machine in actual use casting refined lead and delivering the pigs directly on tram-cars, thus expediting the loading into railroad cars for shipment to market. The machine here shown has a capacity of about 12 tons per hour and requires 3 hp. to operate. During casting, one man looks after the machine and weighs the lead; two other men tram and load the pigs into the railroad cars. Mr. Miller writes that a representative of a smelting company in the United States, after seeing the machine in operation, ordered two casting wheels, each to have a capacity of 15 tons per hour. The pigs as cast are stated to be free from rough edges, shrink holes and dross. The bars are remarkably uniform in weight; four railroad cars, each loaded with 509 pigs, gave net weights of 50,044, 50,031, 50,002 and 49,996 lb. respectively.

Calumet & Arizona Smeltery*

The smelting plant of the Calumet & Arizona Mining Co. comprises a blast furnace, roaster, reverberatory and converter plants, with a sulphuric-acid plant addition under construction and nearing completion. The smeltery treats about 2,427 wet tons daily of ores from the company's own Bisbee mines and about 725 tons of customs ores. The production of blister copper shipped to New Jersey for refining is about 125 tons daily.

Dumped into receiving bins of 3,000 tons' capacity, the ore is crushed in two 24x36-in. Blake crushers and belt-conveyed by two belts to the two units of the sampling mill. A 10% sample here taken is successively recrushed and resampled down to a 160-lb. sample representing 100 tons.

Typical sulphide ores, constituting 50% of the total treated, have the following analyses: Copper, 3.82 to 4.77%; sulphur, 24.8 to 30.9%; iron, 25.4 to 30.9%; silica, 15.2 to 31.1%; Oxides carry: Copper, 4.75 to 5.38%; sulphur, 1.2 to 8.2%; iron, 21.3 to 25.6%; silica, 15.9 to 31%. About 280 tons daily of siliceous customs ores treated average: Copper, 2.15%; sulphur, 3.2%; iron, 5.8%; silica, 75.3%.

From the sampling mill the rejects are conveyed either to the fine or coarse beds—there are three of each, with a coke-storage pile between. The fine beds have a capacity of about 21,000 tons, and the coarse beds hold about 30,000 tons. Two Messiter reclaiming machines take the ore mixture from these beds, discharging it upon conveyor belts leading either to the blast furnace or roaster bins.

The roaster plant at present consists of twelve 21-ft. 6-in. diameter Herreshoff air-cooled roasters, and 12 similar ones are under construction. The fine beds' ore mixture discharges into storage bins of 90 tons' capacity per roaster. The calcines are conveyed in 20-ton electrically operated larries to the reverberatory furnaces. The gases have their dust content settled in a dust chamber 140 ft. long with a 3,300-ft. cross-section, before discharging up the stack.

The roasters treat 96.4 tons per day each, averaging 29.6% sulphur, which is roasted down to about 10%. Each requires about 66,000 cu.ft. of air per minute and produces dust averaging 2.64% of the charge. The calcine and dust product per furnace is 80.5 tons per day.

The blast-furnace department includes two furnaces 40 ft. long by 4 ft. at the tuyeres. Ore mixture from the coarse beds is discharged into bins paralleling the furnaces on both sides, from which traveling charge cars convey the ore to the blast furnaces. Coke is handled through a set of bins parallel to the ore bins.

Both matte and slag overflow continuously into settlers from which the matte is tapped as needed into ladles swung by the overhead cranes into the adjacent converter department. Slag overflows into 225-cu.ft. electrically tilted slag cars hauled by electrical locomotives to the dump. The gases are settled in a chamber 180 ft. long of 2,340 sq.ft. cross-section before discharging to the 305-ft. stack.

Each furnace has 64 tuyeres of 4½-in. diameter, and uses 68,645 cu.ft. of air per ton of dry charge under a pressure of 27 oz. The distance from feed floor to tuyeres is 16 ft. 4½ in. The average capacity per furnace day, exclusive of coke, is 996 tons. The coke percentage of total charge is 12.7, while that of the ores of dry charge is 89.7%; the amount of dust produced is 3.4%.

From ores charged having an average analysis of 5.29% Cu, 13.1% S, 25.9 Fe, 22.2% SiO_2, 5.3% Al_2O_3 and 5.9% CaO is produced a matte averaging 28.81% Cu, 40% Fe and 25.3% S.

The Reverberatory Department

The reverberatory department includes four furnaces whose inside dimensions are 19x100 ft. with a height at the charging end of 8 ft. 3 in., while that at the skimming end is 4 ft. 3 in. The charge and fettling material are introduced through center-drop and side-drop holes respectively. The furnace capacity per day exclusive of converter slag is 400.1 tons.

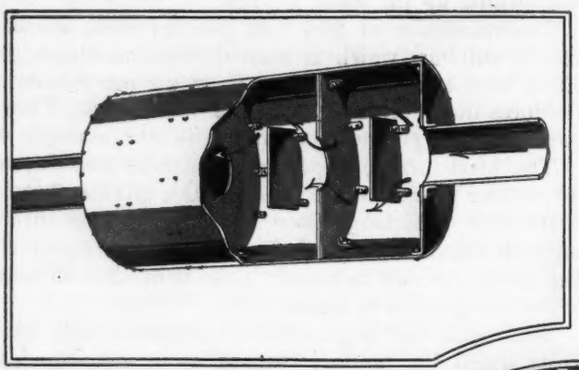
From an average ore charge analyzing 5.16% Cu, 29.3% Fe, 8.5% S, 28.3% SiO_2, 4.1% Al_2O_3 and 3% CaO is produced a matte averaging 25.03% Cu, 41.2% Fe and 26.1% S. The fuel requirement of each furnace per ton of charge is 0.752 bbl.

The converter department includes six stands, with two extra shells, of 12-ft. diameter Great Falls type of basic-lined, electrically tilted converters served by two 40-ton Morgan cranes. The matte, tapped from the blast-furnace settlers or reverberatories into 160-cu.ft. cast-steel ladles, is transferred by the cranes to the converters. The molten slag poured into the reverberatory or blast-furnace settlers has an average analysis of 2.79% Cu. A McGregor skull-breaker handles the skulls, which are resmelted in the blast furnaces.

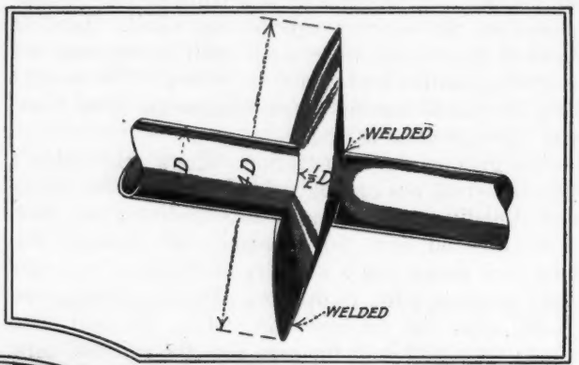
The molten blister copper, which has a purity of 99.16%, is cast in two 40-mold electrically operated straight-line casting machines, the molds for which are made of blister copper in this department.

*Abstract from a booklet descriptive of its plant, printed by the Calumet & Arizona Mining Co. for distribution to visiting members of the A. I. M. E., Arizona meeting, September, 1916.

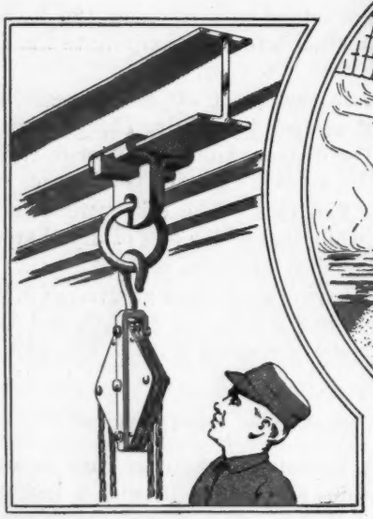
Kinks and Wrinkles



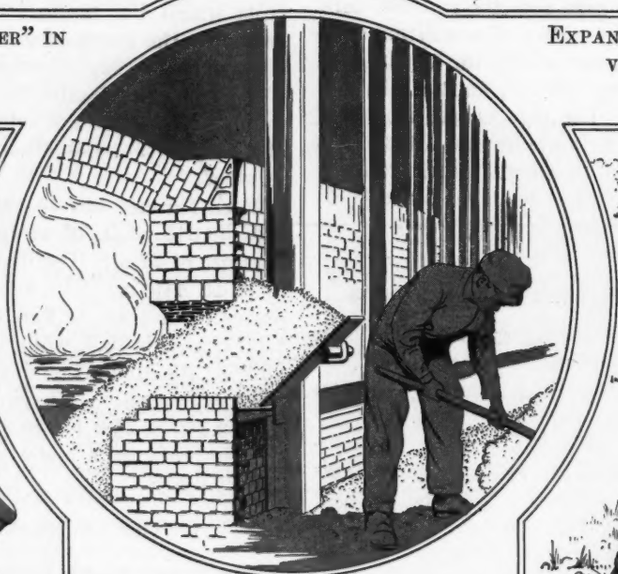
Muffler to Stop "Hammer" in An Air Line



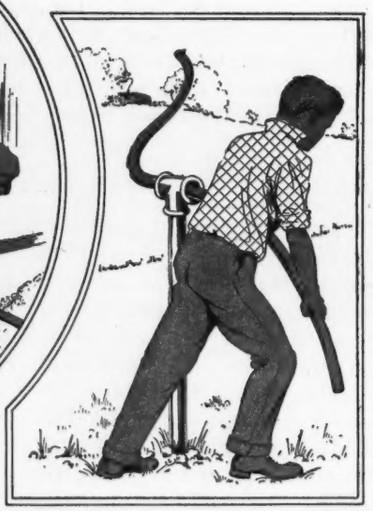
Expansion Joint for Converter Air Line



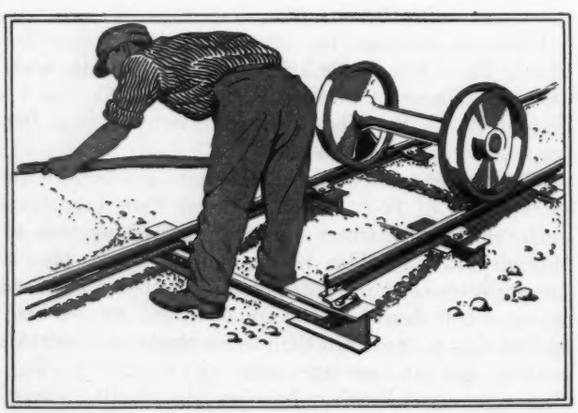
Quickly Detachable Clamp for Rails or I-Beams



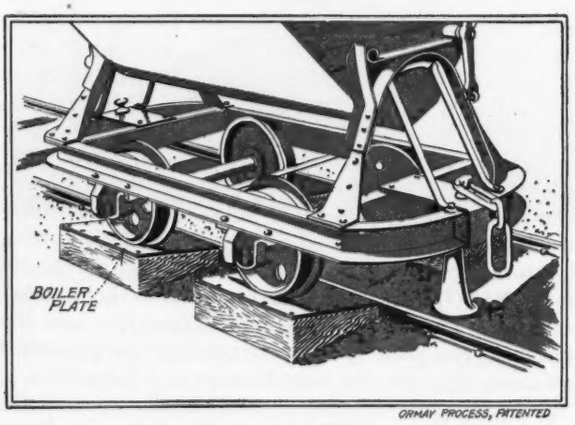
Fettling Used to Replace Side Doors



Bending Pipe in Improvised Field Stand

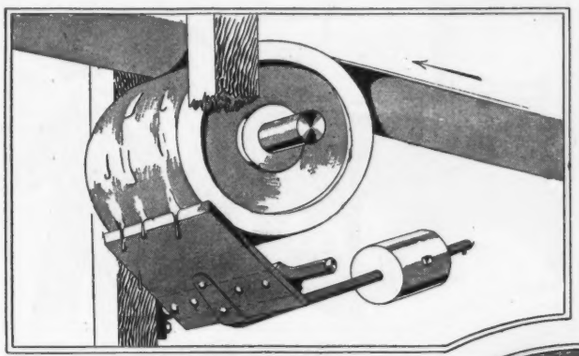


Industrial Track Tie Made from Scrap Structural Steel

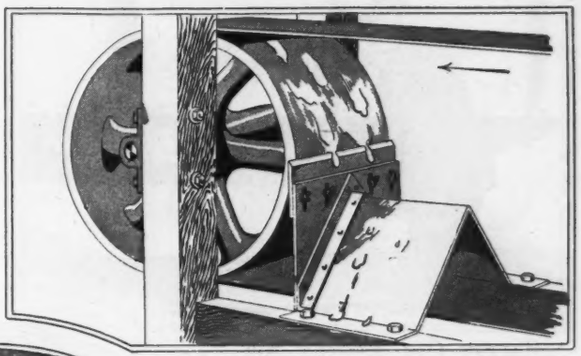


Replacing Derailed Cars with Jack and Blocks

For the Smelting Plant



SCRAPER FOR REMOVING MATERIAL FROM CONVEYOR IDLER

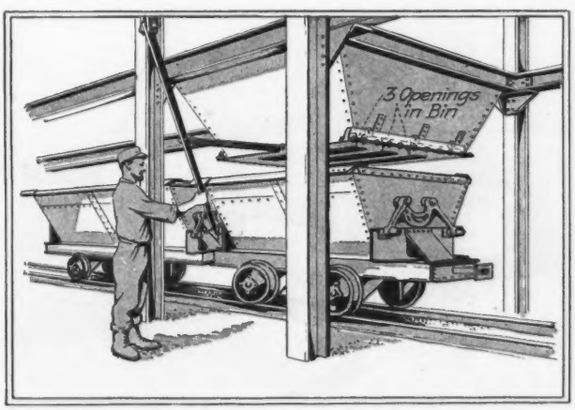


SCRAPER FOR CONVEYOR PULLEY IS MOUNTED ON V-FRAME

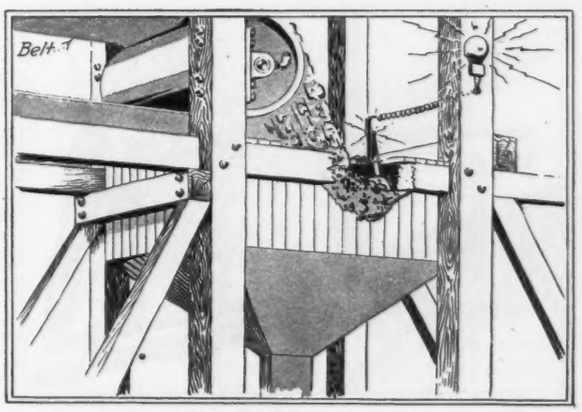
BELT-SHOD SCRAPER TO "SWEEP" STEEL FLOORS

HOIST, AROUND THE CORNER, USED TO UNLOAD HEAVY PACKAGES

HOME-MADE SANITARY DRINKING FOUNTAIN

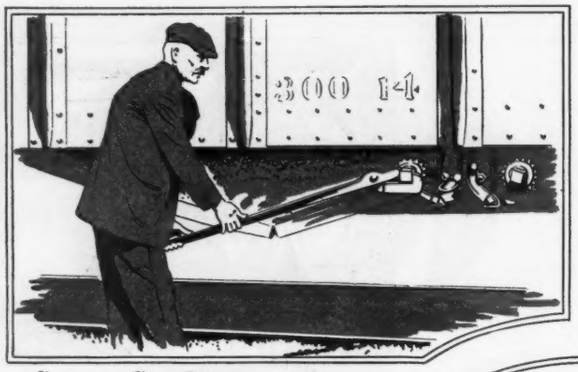


SHALLOW HOPPER AND GATE NECESSITATED BY LOW HEAD-ROOM

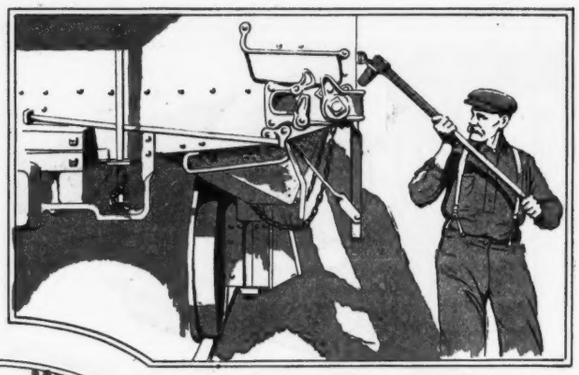


AN ELECTRIC-BELL ALARM FOR ANNOUNCING A FULL BIN

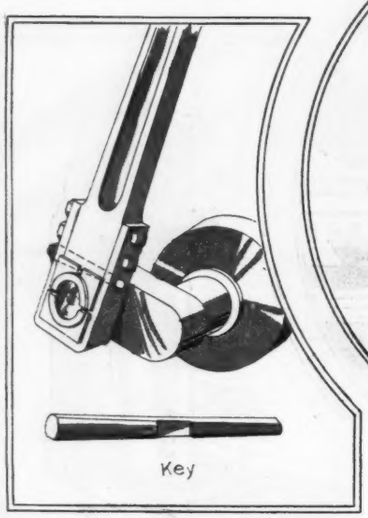
Kinks and Wrinkles



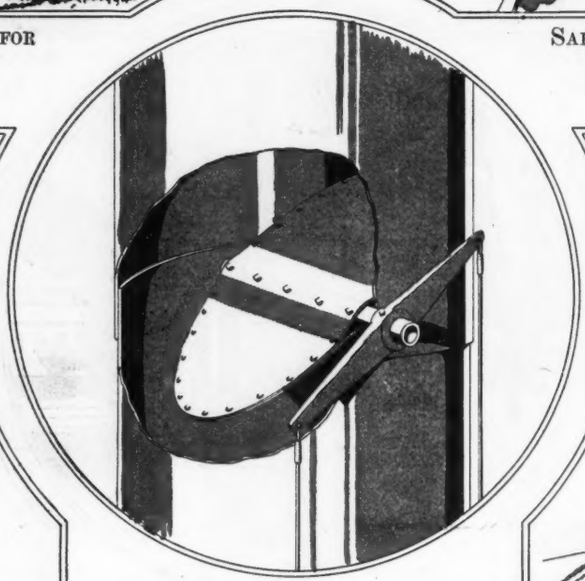
Safety Car Wrench for Bottom-Dump Car



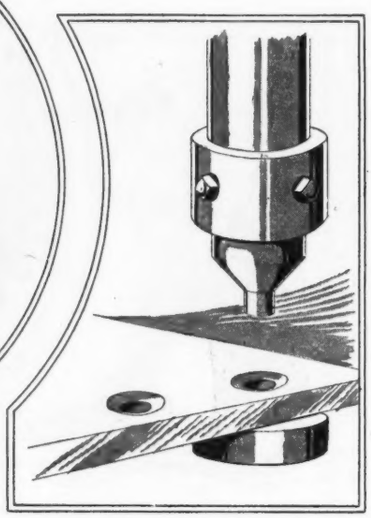
Safety Knuckle Bar for Side-Bottom Dump



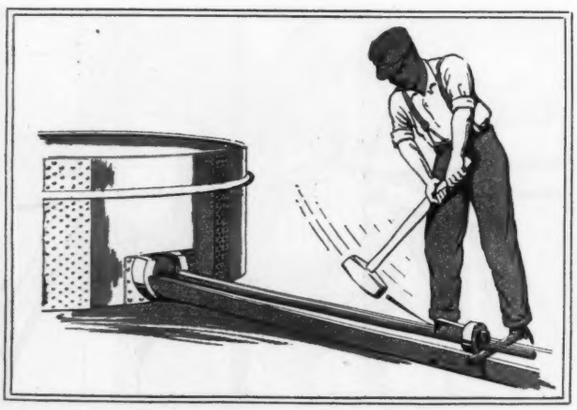
Round Key Saves Making Square Holes



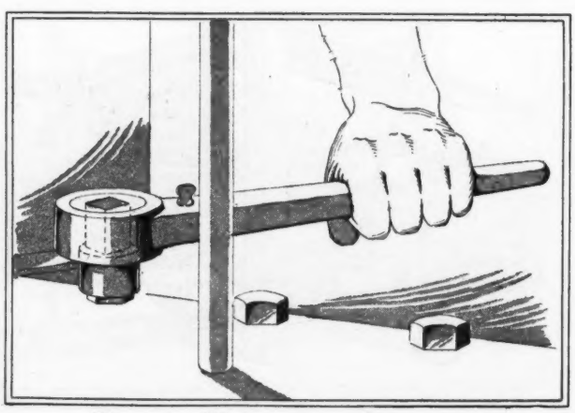
Stack Damper Made from Two Plates and a Pipe



Countersinking Holes with Punch and Die

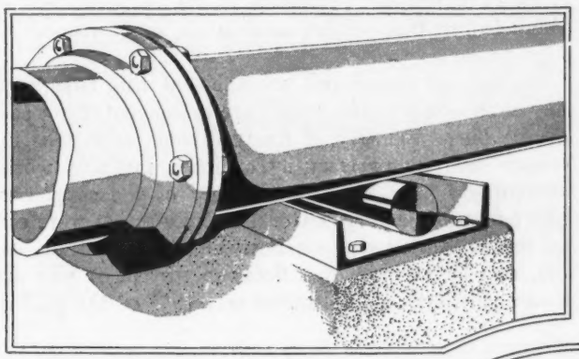


Ring and Wedge for Withdrawing Tapping Bar

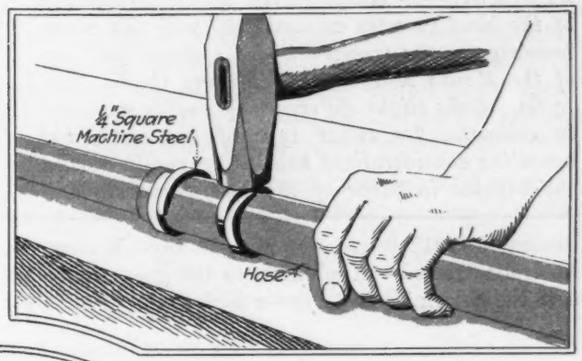


Ratchet Wrench for Places of Small Clearance

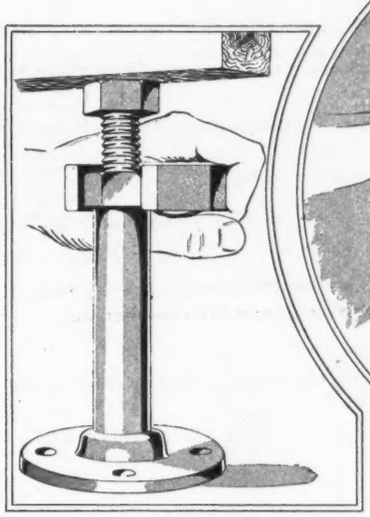
For the Smelting Plant



ROLLER SUPPORT FOR LONG PIPE LINE

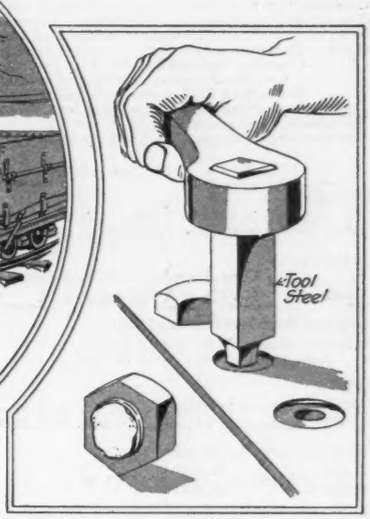


A HOSE CLAMP MADE BY THE SMITH

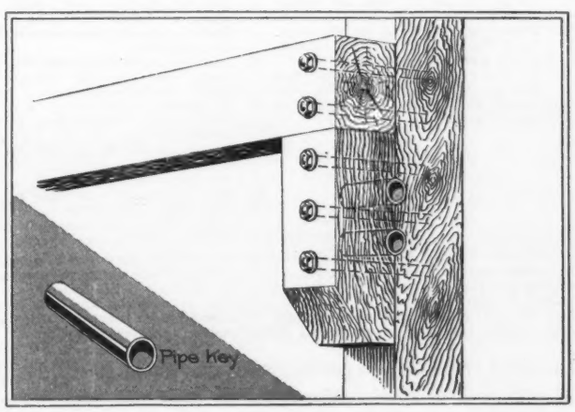


A JACK MAY BE IMPROVISED FROM BOLT, PIPE AND NUT

INEXPENSIVE SWITCH ADAPTED TO LIGHT TRAM SERVICE



A METHOD OF REMOVING BROKEN STUD BOLTS



METHOD OF KEYING BRACKET TO POST WITH ROUND HOLE AND PIPE

SPIRAL CUT TO GET LONG BELT LACE IN AN EMERGENCY

Blast vs. Reverberatory Furnace

By B. Magnus*

SYNOPSIS—A consideration of the advantages of the blast furnace as compared with the reverberatory for the treatment of the copper-gold ore of the Mount Morgan Gold Mining Co. in Australia. Only slight difference in profits indicated in estimates for either type of treatment, but operating considerations and known results turned the balance in favor of the blast-furnace plant.

Previous to 1912 the Mount Morgan Gold Mining Co. in Australia treated—in addition to the gold ore, which went to the chlorination works—a high-grade gold-copper ore in a small blast furnace. About this time it became apparent that there was no more ore available for treatment in the chlorination works and that a modern smeltery would be necessary to treat the large quantity of copper ore which was still available, though of lower value than the copper ore that had been treated previously.

There was in the mine a good deal of ore too high in silica to be smelted profitably, as the company had at all times to buy flux—either as iron ore or pyritic ore—at a high price.

It was not considered profitable at this time to treat any of the lower grade copper ore by concentration because of the large quantity of finely divided free gold in the copper ore; its recovery by ordinary methods would be exceedingly poor, and the recovery of the copper would also be unsatisfactory. Extensive experiments were carried on to devise means of concentrating the low-grade copper ore, and by the use of a flotation process it was proved that about 90% of the copper and 75% of the gold could be saved from an ore running about 2% copper and 7 dwt. of gold. The blocks of ore in the mine were so irregular that a face one day might give an ore which was consigned to the smelting plant and the next day the output from this face would have to be sent to the concentrator, either because it was too high in silica or too low in valuable metals.

BLAST-FURNACE VS. REVERBERATORY SMELTING OF MOUNT MORGAN ORE

(Calculated October, 1912)

Assumptions:

1. Handle monthly 20,000 long tons smelting ores and 15,000 tons concentrating ores.
2. Average grade of ores: Copper, 3%; gold, 8 dwt.
3. Concentration of 2½ tons of ore into 1 ton of concentrates.
4. Roaster-and-reverberatory recoveries: Concentrates—copper, 92%; gold, 96%; crushed ores—copper, 88%; gold 95%. Blast-furnace recoveries: Copper, 85%; gold, 95%. Concentrator recoveries: Copper, 92%, gold, 75%.
5. Costs: Blast-furnace smelting of ore not exceeding 52% SiO_2, $4.29 per ton; extra cost for sintering or melting fines, 24c. per ton.
   Crushing high-grade ores, 24c. per ton; roasting, 72c. per ton; concentrating, 10c. per ton; reverberatory smelting of roasted concentrates, $2.43 per ton; reverberatory smelting of roasted high-grade ore, $3.65 per ton.
   Converting 32% matte from blast furnace, $14.60 per ton of copper.
   Converting 46% matte from reverberatory $9.73, per ton of copper.

Reverberatory Proposal No. 1: Concentrate low-grade ores and crush high-grade ores; roast concentrates and crushed ores, and smelt in reverberatory.
Reverberatory Proposal No. 2: Concentrate all ores, roast concentrates and smelt in reverberatory.

Recoveries

Blast Furnace:

3% copper	× 85% = 2.55%	× 2.92	= $7.44	
8 dwt. gold	× 95% = 7.60 dwt.	× 1.01	= 7.69	
				$15.13

Concentrating:

3% copper	× 92% 2.76%	× 2.92	= $8.06	
8 dwt. gold	× 75% = 6.00 dwt.	× 1.01	= 6.08	
				$14.14

Roasting and Reverberatory Smelting:

2.76% copper	× 92% = 2.53 %	× 2.92	= $7.39	
6 dwt. gold	× 96% = 5.76 dwt.	× 1.01	= 5.84	
				$13.23

Crushed Ore:

3% copper	× 88% = 2.64 %	× 2.92	= $7.71	
8 dwt. gold	× 95% = 7.60 dwt.	× 1.01	= 7.70	
				$15.41

Combined Recovery by Proposal No. 1:

$$\frac{15{,}000}{35{,}000} \times 13.23 + \frac{20{,}000}{35{,}000} \times 15.41 = \$14.45$$

Costs

Blast Furnace:

$4.26 + $0.24 fines treatment + $0.12 Extra Converting Costs..... $4.62

Reverberatory Furnace:

Proposal No. 1:

$\frac{3}{4}$[$1.22 Concentrating + $\frac{1}{2.5}$ ($0.72 Roasting + $2.43 Smelting)] = 1.06

$\frac{1}{4}$ ($0.24 Crushing + $0.72 Roasting + $3.65 Smelting) =..... 2.63

$3.69

Proposal No. 2:

$1.22 Concentrating + $\frac{1}{2.5}$ ($0.72 Roasting + $2.43 Smelting) =. 2.49

Profits

Blast Furnace.....$15.13 — $4.62 = $10.51

Reverberatory Furnace:

Proposal No. 1.....$14.45 — $3.69 = $10.76
Proposal No. 2.....$13.23 — $2.49 = $10.74

In the above calculation of Proposal No. 1, the results are not absolutely correct, due to assuming the same grade of ore concentrated as smelted direct, whereas the first would be lower than the average and the other correspondingly higher; but for the purposes of this calculation, the method of computation is sufficiently correct, more detailed calculation having shown that the error in no instance exceeds 6½c. a ton.

Résumé of Blast-Furnace Smelting

Advantages	Disadvantages
1. Maximum recovery on all ores of higher grade than assumed above and 1,250,000 tons are known to be of higher grade.	1. Handling concentrates and flue dust.
2. More flexible—hence better provision if mine develops high-grade ores.	2. In eight years, present high-grade ores will be exhausted; then there will be no need for blast furnaces.
3. Certainty of continuous operations when changing from old to new plant.	3. Sintering or melting plant will have to be operated for handling concentrates and flue dust to overcome disadvantage No. 1.
4. Erection completed more quickly.	4. Possible serious increases in cost of coke (already $2.75@3.00 per ton of Mount Morgan ore smelted).
5. Recoveries and costs attainable are known.	

Résumé of Reverberatory Smelting

Advantages	Disadvantages
1. Saving in capital cost on power plant and smeltery about $97,000.	1. No experiments ever having been made on concentrating these ores, it is not known what recoveries will be attained.
2. Water supply not a serious item.	2. No trained reverberatory smeltermen, hence possible serious delay when starting new plant.
3. No difficulty in handling concentrates and flue dust.	3. Extensive experiments will need to be made on settlement of roaster dust and may involve big outlay of capital (M. S. concentrates very fine).
4. No Many Peaks ore would be used and in Proposal No. 2 neither Many Peaks ore nor ironstone would be used.	4. Coal must all come from Newcastle.
	5. Lay of ground not very suitable.
	6. Excellent recoveries and costs assumed but not definitely known if they can be attained.

Memo. Added January, 1915: The recoveries indicated for the concentrator are not as yet attainable. The recoveries for the reverberatory smelting, particularly considering roaster losses on Minerals Separation concentrates, as indicated, are better than it is now considered possible to obtain. The cost for concentrating indicated is not yet attained. The costs indicated for roasting and reverberatory smelting are the best that might be hoped for after years of experience. It is therefore apparent that reverberatory smelting at Mount Morgan could not be considered desirable with the possible exception of roasting and smelting the concentrates, now produced, in reverberatories direct to high-grade matte. In view of the heavy dust losses which might be looked for on roasting M.S. concentrates, and the cost of a roasting plant, it would appear as if it is desirable either to melt or sinter concentrates and smelt the product in the blast furnaces.

*Consulting engineer, 61 Broadway, New York.

At that time it was therefore impossible to determine definitely how much of the ore in the mine would be concentrated and how much smelted. The amount of high-grade ore was definitely known, but it was anticipated that this quantity would be augmented by the richer portions of ores which previously were calculated in the average of the leaner ores. It was therefore anticipated that a larger quantity would be available for blast-furnace treatment than the reserves showed. Before undertaking the design of the new plant, calculations as set forth in the accompanying table were made and show why a blast-furnace plant was finally determined upon.

Metallurgical Calculations as Affecting Mine Valuation

By B. Magnus*

Soon after starting smelting operations in the new Mount Morgan plant in Queensland, Australia, it became apparent that the monthly net earnings did not correspond with what might have been expected when deducting the cost of mining and treatment from the reported value of the recovered metals in the ores. Upon investigation, it was found that while the assays of the ores treated over a long period corresponded fairly well with the mine-assay plans, there was great variation day by day in ore coming from the same blocks. Mine-assay plans were therefore rearranged into blocks of more nearly uniform grades even though the ore could not be mined in accordance with the indication of this regrouping. The calculations then made are shown in Table 1. Early in 1912 the mine reports showed 1,500,000 tons of high-grade and about 2,000,000 tons of medium-grade ore.

TABLE 1. DETAILED EXAMINATION OF ORE RESERVES TO DETERMINE PROPER TREATMENT FOR THE VARIOUS BLOCKS

	Block No. 1 SiO_2	Block No. 2 SiO_2	Block No. 3 SiO_2	Block No. 4 SiO_2	Block No. 5 SiO_2	Block No. 6 SiO_2	Block No. 7 SiO_2	Block No. 8 SiO_2	Block No. 9 SiO_2	Block No. 10 SiO_2	Block No. 11 SiO_2	
Actual SiO_2..	58.5	56.9	52.5	51.0	48.4	46.9	43.8	41.3	41.2	38.5	34.0	
$SiO_2 + 2\%$[12]	60.5	58.9	54.5	52.1	50.4	48.9	45.8	43.3	43.2	40.5	36.0	
Gross Value per Long Ton	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	Tons Ore	
$23.98	.....	.....	.....	.....	.....	.....	312,000[7]	.....	.....	.....	.....	
22.89	.....	.....	36,500[3]	.....	.....	.....	.....	.....	.....	.....	.....	
22.55	86,000[1]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
20.67	.....	166,000[2]	.....	.....	.....	.....	.....	.....	.....	.....	.....	A
19.78	.....	.....	.....	.....	.....	276,500[5]	.....	.....	.....	.....	.....	
16.03	.....	.....	.....	.....	246,000[6]	.....	.....	.....	.....	.....	.....	
17.71	.....	.....	.....	1,000[4]	.....	.....	.....	.....	.....	.....	.....	
12.73	.....	.....	.....	.....	.....	.....	.....	.....	370,000[9]	.....	.....	
11.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	151,900[10]	.....	B
11.42	.....	.....	.....	.....	.....	.....	.....	78,800[8]	.....	.....	.....	
8.62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	190,000[11]	

Treatment Costs, Recoveries and Profits	S[15]	C[16]	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C
Mining.....	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41
Conc'tr'g, etc.	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58	....	1.58
Smelting.....	6.30	.85	6.08	.85	5.41	.85	5.04	.85	4.78	.85	4.53	.85	4.07	.85	3.68	.85	3.68	.85	3.26	.85	2.50	.85
Conv. and realiz.....	1.64	1.44	1.60	1.42	1.84	1.62	.38	.32	1.44	1.28	1.74	1.54	2.19	1.92	1.07	.93	1.58	1.40	1.60	1.41	1.17	1.03
General expenses.....	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49	.49
Total cost....	11.84	7.77	11.58	7.75	11.15	7.95	9.32	6.65	10.12	7.61	10.17	7.87	10.16	8.25	8.65	7.26	9.16	7.73	8.76	7.74	7.66	7.36
Yield.....	21.17	16.98	19.32	15.59	22.22	18.02	17.15	13.14	14.88	12.12	18.39	14.94	22.26	18.12	10.58	8.63	11.57	9.74	10.48	8.96	7.76	6.58
Profit per ton	9.33	9.21	7.74	7.84	11.07	10.07	7.83	6.49	4.76	4.51	8.22	7.07	12.10	9.87	1.93	1.37	2.41	2.01	1.72	1.22	.10	....

Detailed Value of Ore in Individual Blocks of Mine[13]

	Metals	Content	Gross	Value per Ton Recovered By Smelting	Value per Ton Recovered By Concentrating
[1]Block 1...	Gold	12.78 dwt.	$12.94	$12.70	$9.10
	Copper	3.30%	9.65	8.47	7.46
[2] Block 2..	Gold	11.13 dwt.	11.28	11.04	8.28
	Copper	3.23%	9.40	8.27	7.29
[3] Block 3..	Gold	11.92 dwt.	12.07	11.82	8.86
	Copper	3.71%	9.87	8.68	9.16
[4] Block 4..	Gold	15.30 dwt.	15.30	15.18	11.37
	Copper	0.76%	2.23	1.94	1.73
[5] Block 5..	Gold	7.49 dwt.	7.58	7.44	5.57
	Copper	2.90%	8.47	7.44	6.54
[6] Block 6..	Gold	9.78 dwt.	9.97	9.71	7.27
	Copper	3.51%	10.24	9.03	7.93
[7] Block 7..	Gold	11.06 dwt.	11.22	10.97	8.21
	Copper	4.39%	12.84	11.29	9.93
[8] Block 8..	Gold	5.06 dwt.	5.73	5.04	3.77
	Copper	2.13%	6.30	5.55	4.87
[9] Block 9..	Gold	3.43 dwt.	3.45	3.40	2.55
	Copper	3.18%	9.29	8.17	7.19
[10] Block 10	Gold	2.22 dwt.	2.24	2.19	1.65
	Copper	3.23%	9.44	8.30	7.30
[11] Block 11	Gold	1.77 dwt.	1.80	1.75	1.33
	Copper	2.34%	6.84	6.00	5.28

Regrouping of Ore Reserves

	Tons Ore	Profit	Obtained Metals Gold, Oz.	Copper, Tons
A Group: High-grade ore.....	1,123,000	$9,707,670 $8.63 per ton	557,579	35,279
B Group: Medium-grade ore.....	791,700	1,333,284 $1.68 per ton	11,529	20,088

Blocks 8, 9, 10 and 11 will be concentrated because when crediting them with iron contents recovered in concentrating, they will show at least same profit by concentrating as by smelting.

Details of Treatment Costs

Smelting Ore

Mining	$3.04 + $0.37 = $3.41 per ton
Smelting	$2.19 per ton, gross burden
Fluxing	$0.10 per unit, excess SiO_2
Converting	$0.14 per 1% copper recovered
Realization	$0.42 per 1% copper recovered
General expenses	$0.49 per ton

Concentrating Ore

Mining	$3.41 per ton
Concentrating, etc.	$1.09 per ton
Royalty	$0.12 per ton
Sintering	$0.36 per ton
Smelting	$0.85 per ton
Converting	$0.14 per 1% copper recovered
Realization	$0.42 per 1% copper recovered
General expenses	$0.49 per ton

Copper recovery: By concentration, 88%; by smelting, 88%.
Gold recovery: By concentration, 75%; by smelting, 98%.

$$\text{Fluxing} = 5\left(S - \frac{100 - S}{2}\right)$$

where S = silica content + 2.

[12] Arbitrary addition of 2% for metallurgical calculations.

[13] In original chart, these data are shown with the tonnage figures for ore in each block. Space, however, did not permit of that arrangement on this page.

[14] Copper taken at 13c. per lb.; gold at $1.01 per dwt.

[15] S = Figures relative to treatment by direct smelting.

[16] C = Figures relative to treatment by concentration and smelting.

If it had been possible to operate a reverberatory plant at anything like the cost obtainable in American plants, then the proposal to concentrate the leaner ores and to crush and roast all the high-grade ores would have been the best proposal, but on account of the cost of labor and material, no low reverberatory-smelting costs could be achieved. Further, the cost of reverberatory smelting would probably constantly increase, whereas there was no similar reason for expecting the blast-furnace costs to rise.

*Consulting engineer, 61 Broadway, New York.

It was considered that all the high-grade ore would be smelted and, in addition, a certain amount of ore from the medium-grade bodies, but after a study of Table 1 it became apparent that the figures given were by no means the tonnages available for the specified treatment.

When the ore reserves were resurveyed, a different condition was found to exist. Blocks 8, 9, 10 and 11 are good examples of the result of a detailed study of the different ore blocks. These medium-grade blocks show a fair profit by smelting, and being low in silica as compared with the high-grade blocks, they were regarded as desirable smelting ores. Nevertheless, it was decided to concentrate these blocks. It will be noted by the table that the blocks show a slightly higher profit by direct smelting than by concentration. However, for metallurgical reasons, the latter treatment was decided upon, the increased iron tenor of the concentrates entitling the concentrating treatment to a metallurgical credit so that, properly, concentration showed at least as great a profit as direct smelting and the excess iron in the concentrates reduced the amount of ironstone to be imported for fluxing the siliceous ores.

To the engineer closely in touch with a property there would not be much surprising in these results, but the average man is accustomed to considering total reported tonnage of ore at average value as being the assets of a mining property. The error in this is shown by Table 2, which is an exaggerated example, but calls attention to the advisability of reporting mine reserves according to the grades of ore within strict limitations. Table 1 further shows the necessity of metallurgical consideration being given to the grades of ore in the mine before any figures dealing with reserves are reported.

Furthermore, an investor often lumps the amount of metals that will be produced from the published ore reserves of the mine, whereas the most economical working of the property might mean a decidedly lesser quantity of metals produced. It is reasonable to wish to publish all ore reserves—including those that are not immediately profitable but may be in the future—but it would be advisable to publish these entirely separate from other figures, so that the figures as presented to the public would enable the discriminating investor in mining properties to estimate from time to time, the value of his investment with almost the same degree of accuracy as in estimating the earning capacity of an industrial enterprise.

TABLE 2. SHOWING PROFIT ON ORE RESERVES CONSIDERED AS A WHOLE AND IN SEGREGATED BLOCKS

Ore Reserves, Tons	Copper, %	Gold, Oz.	Recovered Metals Copper, Tons	Recovered Metals Gold, Oz.	Value Recovered, Metals—Copper	Value Recovered, Metals—Gold	Value Recovered, Metals—Total	Value, Less Mining and Treatment at $10 per Ton
(A) 1,000,000	4	0.1	36,000	100,000	$10,800,000	$2,000,000	$12,800,000	$2,800,000
(B) 600,000 (6%)	4	0.1	32,400	60,000	9,720,000	1,200,000	10,920,000	4,920,000
400,000 (1%)								

The block of 400,000 tons of 1% ore in (B) would not be mined. On the basis of 4,000 tons copper produced per annum, the mine life would be nine years in case of (A) and amortization would be 12½% per annum, whereas in (B) life would be eight years and amortization 14½%. Daily smeltery capacity in (A) would be 300 tons, in (B) 200 tons, and amortization in (B) would probably be $50,000 yearly less than in (A). If it were decided to smelt 300 tons of ore daily in either case, then life in (B) would be only 5½ years, but production would be 5,800 tons copper annually from a smeltery which cost the same to build as in (A).

The Direct Production of Iron-Nickel Alloys

In order to avoid the separate extraction of iron and nickel, or iron and any other metal, such as manganese, from an ore when it is possible to obtain a desirable alloy by direct reduction, Frederick A. Eustis, of Milton, Mass., and Charles P. Perin, of New York, have devised a process for the direct production of such alloys.

Taking Cuban ore as an example, containing about 1% nickel, a lot of ore is divided into two parts, one of which is to be treated for the extraction of a predetermined amount of its nickel, which is subsequently added to the second part, thereby enriching the mixture in nickel. Then the mixture is smelted to produce an iron-nickel alloy. The treatment of the first part of the ore for the extraction of nickel may be accomplished by roasting with sulphur-bearing material, yielding a sulphated product from which nickel sulphate can be leached. The nickel solution thus obtained may be precipitated and the precipitate added to the second part of the ore prior to smelting. The inventors have been granted U. S. Patent No. 1,185,187.

Safe Practice at Blast Furnace

In Technical Paper 136 of the United States Bureau of Mines, the subjects of accidents and their prevention has been dealt with in a painstaking manner. This paper is a manual for foremen and men, telling each class of workmen of the things which they should do and the things which they should not do—principally the latter.

The paper is amply illustrated, to the extent that a mere child would find the book an interesting one; thus exploding the popular fallacy that government publications are dull and uninteresting. One set of three pictures, showing the improper and proper way of transporting a dinner bucket from the bottom of a ladder to an elevated platform, should appeal to mine managers; though it is questionable whether the Bureau of Mines will insist upon the adoption of this system for underground use. Reel 1 shows "Taking Chances on a Ladder, Carying Bucket in One Hand"; Reel 2, "Man Falls from Ladder" (presumably Monday morning); Reel 3, "The Safe Way; Haul Up the Bucket with a Line."

If each and every workman about a blast furnace were to carry a copy of this manual in his hip pocket and obey implicitly all the instructions therein provided for his individual guidance, it is difficult to conceive how any accident, however trivial, could happen to any one but a rank intruder or an ignorant wop. But should anything transpire, turn to page 62 and consult the notes on first aid. A first-aid box in the charge of the chemist, storekeeper or watchman is recommended as an encouragement for the workmen to form the habit of seeking immediate first-aid treatment for slight injuries. Every wound should be primarily looked upon as infected and receive immediate attention. A fresh cut should not be washed, even by the first-aid man; leave that for the physician. For details of first aid, bandaging, use of splints, stretcher work and methods of resuscitation, see Miners' Circular 23[1].

[1] "Elementary First Aid for the Miner," Miners' Circular 23, Bureau of Mines, 1916. (In press.)

Lead-Smelting Practice in the United States

By Arthur S. Dwight*

SYNOPSIS—Recent lead-smelting practice has not changed greatly, the advances being chiefly in refinements in the preparation of the charge and in the handling facilities to permit better metal recoveries. Economy in labor, improved furnace operation and higher recoveries have resulted. Double roasting has permitted sulphur content to be reduced to 2.5% by automatic apparatus, hand roasting having almost completely disappeared. Newnam hearth promises rejuvenation of Scotch-hearth type of furnace for smelting the highest grade lead concentrates.

A review of the field of lead smelting in the United States shows that most of the recent progress in the art has been made (*A*) in the methods of preliminary preparation of the furnace charge, including desulphurization and the agglomeration of fines, and (*B*) in the better handling facilities that have been devised for making up the furnace mixtures, whereby not only economy in labor, but improved furnace operation and better metal recoveries are attained.

It is not the purpose of this article to record in detail even a fraction of the many individual or minor improvements in apparatus and method that have been worked out and that in the aggregate have done much to improve conditions, but rather to treat the subject in a broad way, and with especial emphasis on the two phases of the question named.

The lead-smelting plant of today, excluding the refineries in which ore smelting is merely incidental, consists essentially of (a) blast furnaces with auxiliary equipment, (b) roasting plant, (c) power plant, (d) facilities for weighing, unloading, sampling, storing the ores and fluxes, handling them through the intermediate stages of the operation, and at last making up the proper smelting mixture and delivering it to the furnace; (e) means for handling, separating and disposing of the molten products from the furnace; and finally (f) means for the collecting and disposal of flue dust, fume and waste gases (chiefly SO_2) from the roasting and smelting furnaces in such manner that the health of the workmen is safeguarded and the least possible injury may be caused to persons and property in the environment. This article will discuss only the items (a), (b), and (d).

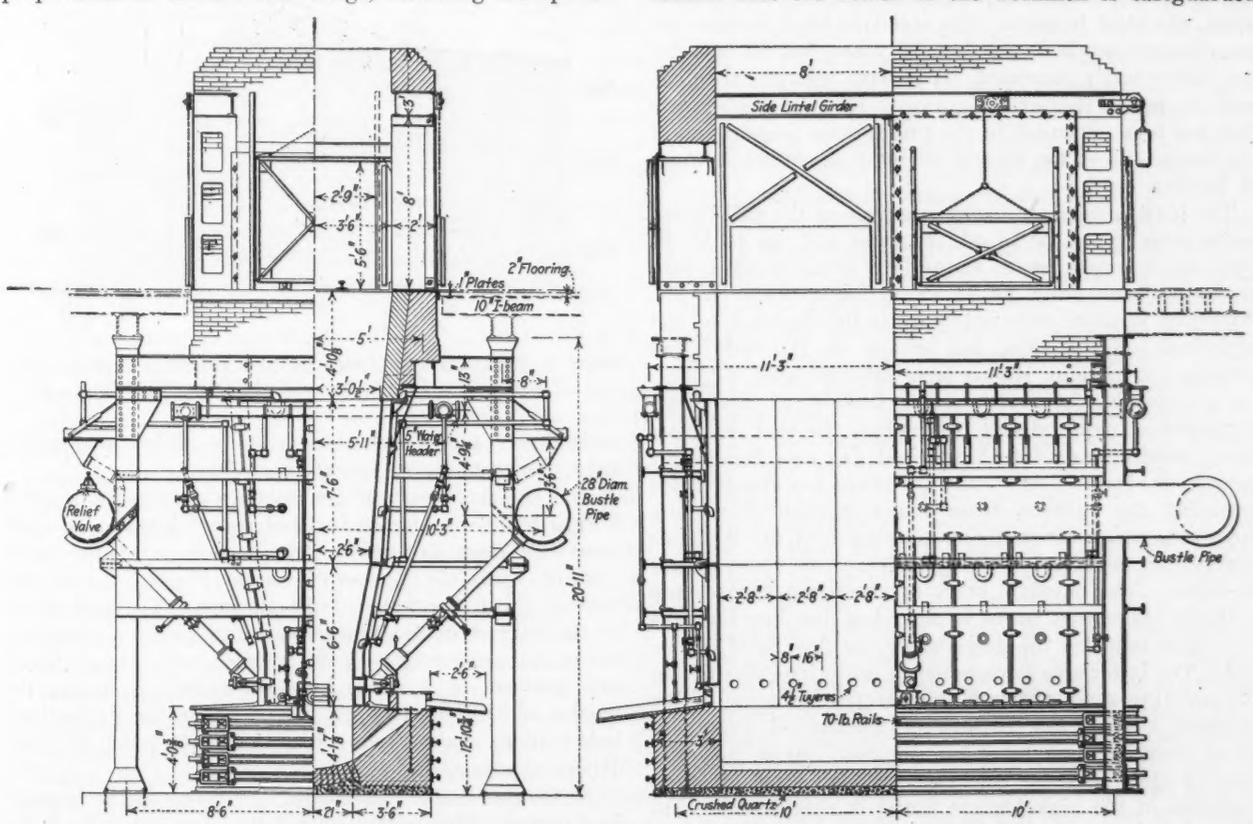


FIG. 1. END AND SIDE ELEVATIONS OF 42x192-IN. LEAD-BLAST FURNACE IN REMODELED PLANT OF NORTHPORT SMELTING AND REFINING CO., AT NORTHPORT, WASH.

No attempt will be made to discuss the power plant, the handling, separating and disposing of the molten product of the furnace, or of the smoke question. The last-named subject, especially, has in the last few years been under investigation by the brighest minds and the

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most skillful scientific methods that the large smelting companies could command. Much valuable matter has been published already in connection with smoke suits in Utah, Montana and California, but an enormous amount of data has been gathered which is as yet unpublished, but which it is hoped may some day be presented.

Modern American lead-smelting practice is, almost without exception, based on a preliminary treatment of all ore fines for purposes of desulphurization and agglomeration by either the Huntington & Heberlein, or the Dwight & Lloyd systems. Thus in the 25 most important lead smelteries in the United States, Mexico and Canada (excluding refineries, unless they also treat crude ores, all but two have D. & L. sintering equipment; 10 have H. &. H., 23 have D. &. L., while eight of crude ores), all but two have D. & L. sintering equipment; operating side by side. Therefore I cannot well avoid frequent references to a process in which I am naturally peculiarly interested, but will try to treat this phase of the subject as merely incidental to the general discussion and in as impartial a spirit as possible.

The Standard Lead Blast Furnace

I shall first deal with the central figure in the smelting plant, the blast furnace. The standard blast furnace has not changed much in the last 10 years, but its capacity has been greatly increased, its general behavior steadied, and its metal recoveries improved by the greater care that has been expended in the preliminary preparation of ore charge and in the general adoption of correct methods of feeding.

The blast furnaces in common use are of the well-known rectangular type, 42 to 44 in. wide and up to 18 ft. long, inside measurement at the level of the tuyeres, with an ore column from 14 to 18 ft. high; water jackets extending in some cases nearly up to the charge floor and with bosh on the sides, but seldom on the ends; lead crucible with Arents' siphon tap; water-jacketed slag tap; large removable forehearth settler from which the matte is tapped as required and from which the slag overflows nearly continuously into large-sized slag cars handled by electric or steam locomotives; a furnace top arranged for removing the furnace gases and a mechanical feeding apparatus which is usually an adaptation of the Williams charge car and the Dwight spreader,[1] both more or less modified. The old-style brick or sheet-iron furnace top with downtake pipe, seems to make less flue dust than the style that removed the gases below the floor level at one end. The latter also is supposed to cause irregularities in the smelting zones through the unequal influence of the chimney shaft. For reasons of mechanical simplicity when charging cars are used, the low top is generally used in spite of these objections, though some excellent examples of the high top are found in combination with the car.

Fig. 1 shows a furnace that may be taken as a fair example of good modern practice. It represents the furnace recently designed for the Northport smelting plant by the manager, Samuel James, and fabricated by the Traylor Engineering and Manufacturing Co., of Allentown, Penn. Three of these furnaces were successfully started up this year and are making an excellent record. It is particularly interesting because, although served by a charge car, the high top is adhered to.

The following comments on the structural features of this furnace may be pertinent: The area of the smelting zone is 42x192 in. at the tuyere level, with an ore column approximately 18 ft. high. The side water jackets are 32 in. wide, arranged in an upper and a lower tier. The lower jackets are 6 ft. 6 in. high with bosh and two tuyere openings 4½ in. diameter on 16-in. centers, making 16 tuyeres on each side of the furnace. The upper jackets are 7 ft. 6 in. high and set so as to continue the bosh upward though at a lesser angle than on the lower jackets. Special attention is directed to the arrangement of the columns and mantle beams supporting both the superstructure of the furnace and the charge floor, which, by the wide spacing of the columns, gives free working space when it becomes necessary to change jackets. The water-pipe system can be swung out of the way, likewise the tuyere pipes and fittings. Besides back-pressure relief valves on the bustle pipe,

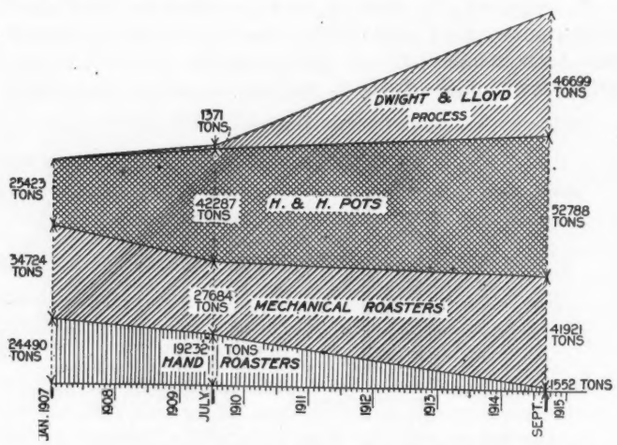


FIG. 2. GRADUAL CHANGE IN ROASTING METHODS AT 10 IMPORTANT U. S. LEAD SMELTERIES

each tuyere pipe is provided with an Eilers automatic tuyere valve to guard against back-fire.

The superstructure of the furnace consists of a steel and cast-iron framework inclosed in red brick. On each long side there are doors which can be used for hand feeding when the furnace is being blown in and for barring down the walls of the furnace. The end doors of the superstructure are arranged to admit a charging car of the same length as the furnace, which is switched into position by a steam locomotive and discharges its burden of 8,000 lb. through drop doors in the flat bottom held shut by chains from a windlass shaft, much like the Hixon charge car.[2]

As the problem of distributing the charge in the furnace is a comparatively simple one, 70% of it being D. & L. sinter, a small longitudinal spreader placed a short distance below the car is sufficient. Such a furnace as here shown will smelt about 250 short tons of charge per 24 hr., or about 4½ tons of charge per square foot of area at the tuyeres, with a blast pressure of 30 to 40 oz., using a fuel charge equivalent in fixed carbon to 10 to 11% of the weight of the charge, besides 3% sulphur. The matte is about 7%, assaying 10 to 12% Pb, and

[1] "The Mechanical Feeding of Silver-Lead Blast Furnaces," by A. S. Dwight. "Trans. A. I. M. E.," Vol. XXXII, 1902. See also L. D. Anderson, "Eng. and Min. Journ.," May 20, 1916.

[2] "The Mechanical Feeding of Silver-Lead Blast Furnaces," by A. S. Dwight, "Trans. A. I. M. E.," Vol. XXXII, 1902.

the slags about 0.5% Pb. The amount of lead in the charge is about 25%.

A satisfactory roasting process for lead smelting must effect a maximum elimination of sulphur and leave the product in coarse form. The latter point has now come to be regarded as almost of equal importance with the former. The higher percentages of sulphur can be disposed of satisfactorily by the old-style mechanically rabbled roasting hearth and economically too, if one is satisfied with 10% or more residual sulphur. The finishing roast can be performed either in H. & H. pots or D. & L. machines, both of which yield a coarse product in excellent condition for the subsequent blast-furnace smelting, and with residual sulphurs running from about 2½ to 5%. If this preroasting were omitted with heavy sulphides and they were subjected at once to a blast-roasting operation adjusted to produce the maximum percentage of agglomerated product, the mass of sulphide particles would tend to fuse or matte prematurely in the intensity of the oxidation induced by the forced draft and this layer of matte would tend to shut off the further passage of the air blast. Blast roasting is most successful on a charge in which the sulphide particles are mixed with other particles of more or less refractory material, so chosen that during the first, or roasting, period they shall remain inert, acting as isolaters to prevent mass action among the burning sulphide particles, but which subsequently, during the second or sintering period, shall be capable of chemical reaction with the metallic oxide produced by the roasting to form silicate or other similar compound, which at the moment of nascency will become sufficiently fluid at the intense temperatures developed by the reaction, to be performed by the air blast into the peculiar cellular or cokelike mass now called sinter.

Sulphur Limit 16 to 18% for Good Sintering

A sintering charge for the H. & H. pot or D. & L. machine will usually be limited to 16 or 18% sulphur—usually less. This tenor may be obtained with heavy sulphides either by partly desulphurizing them beforehand, as previously suggested, or by mixing the crude sulphide with other fine materials lower in sulphur, such as flue dust, siliceous and oxidized ore screenings or other material that it may be desirable to sinter, until the sulphur is sufficiently diluted for effective treatment by the sintering process. Thorough mixing of the ingredients is highly essential in order to bring about the complete isolation of the separate sulphide particles from one another to meet the ideal conditions outlined. Both these methods are sometimes followed in the same plant.

The type of furnace originally adopted for this purpose in the H. & H. plants in this country was the Godfrey, in which the ore is carried on a revolving circular hearth fired by coal and stirred by stationary rabbles extending down through the dome roof. The simplicity of this furnace recommends it, but it has the objection common to all the old-style mechanically rabbled roasting hearths; namely, that it is difficult to prevent wide variations in temperature on the roasting hearth, and this lack of heat control followed by premature fusion of the unroasted sulphides is what killed the mechanical roasters for treating lead ores—so extensively introduced in the Rocky Mountain region back in the 90's.

The precise temperature control possible with the modern Wedge furnace led me to believe that with it the difficulties that had formerly been considered insuperable objections to using mechanically rabbled roasting hearths for roasting easily fusible sulphides could be obviated. On my recommendation, a Wedge furnace was installed by the St. Joseph Lead Co. at Herculaneum, Mo., early in 1911 to preroast leady matte. This was the first Wedge furnace installed for lead ores and behaved so satisfactorily that many other smelters have installed the same type and the Wedge may now be considered as standard practice for preroasting, especially in connection with sintering operations.

Extinction of the Hand Roaster

The old hand roaster, which has been for so many years the unfailing friend of the lead smelter, has been rendered practically obsolete in the United States by the development of the modern roasting methods and the successful revival of the mechanically rabbled furnaces for preroasting. A few survivors may be found still standing, here and there, but with little work to do.

In this connection the diagram shown in Fig. 2 may be of interest. It represents the tonnages being treated by the various roasting processes in 10 representative lead-smelting plants in the United States for a period of about seven years, from the time the first D. & L. plant was built in the United States until September, 1914, by which time the D. & L. tonnage had grown to about equal that of the H. & H. tonnage in these plants, while the hand roasters had dropped to almost nothing.

The D. & L. system is so flexible that it can be made to perform either the preroasting of charges high in sulphur without sintering, or the finishing roast of a charge with a lower initial sulphur to yield a superior quality of sintered product, but it cannot do both satisfactorily in a single operation. The use of the D. & L. machine as a preroaster is a recent development in this country, but has been practiced in Australia since the D. & L. process was first introduced at the Port Pirie works of the Broken Hill Proprietary Co. in 1908. This company uses one battery of D. & L. machines for preroasting and another for sintering. Several American plants have within the last year found that they could preroast on their D. & L. machines more cheaply than by their Godfrey or Wedge furnaces and then finish either in their H. & H. pots or by another pass over the D. & L. machine. This procedure has been called "double roasting," and will be discussed later.

Numerous references to the H. & H. pot plants now in operation in the United States may be found in current technical literature. Therefore no attempt will be made in this article to describe them. As the American Smelting and Refining Co. owns the American rights to the H. & H. patents, they are the sole users in the United States. No important changes have been made in their design, nor in fact, have any new installations or increases in old ones been made, as far as I am aware, in the last seven or eight years. The single plant of the Savelsberg process in the United States, at the Herculaneum, Mo., plant of the St. Joseph Lead Co. was shut down about four years ago after the D. & L. system had demonstrated its greater economy. The Salvesberg plant consisted of 29 pots and accessories.

Neither will any elaborate description be attempted of the D. &. L. process. Numerous descriptions of plants have been published which give full information, and

the general subject is now well understood. The plants recently constructed are substantially built, with steel buildings and complete equipment for economically handling the ores, automatically proportioning the ingredients, mixing and moistening. The feeding system generally employed is one that was developed by Dwight & Lloyd, and will be more fully described in the paragraphs on "The Handling of the Materials."

New Bunker Hill Roasting Plant

A typical arrangement of a roaster plant containing a Wedge roaster and four D. & L. machines is shown in Fig. 3. It is the roaster building for the new Bunker Hill smelting works at Kellogg, Idaho, which is being built by Bradley, Bruff & Labarthe, of San Francisco, Calif., by whose courtesy these drawings are published. Automatic proportioning of ingredients will be used, the same system of belts supplying both the Wedge furnace and the D. & L. machines. The preroasted product of the Wedge furnace will be returned by tram-cars to the main ingredient bins, from which it can be again fed into the charge to the sintering machines.

The sintering machine itself has not been modified to any serious extent since the present standard type was adopted six years ago. While it has been frequently claimed by critics that the construction is entirely too light for the work it is called upon to do and beginners have almost invariably been ready to recommend many changes, the machines have shown such endurance under the most difficult service and such flexibility under all

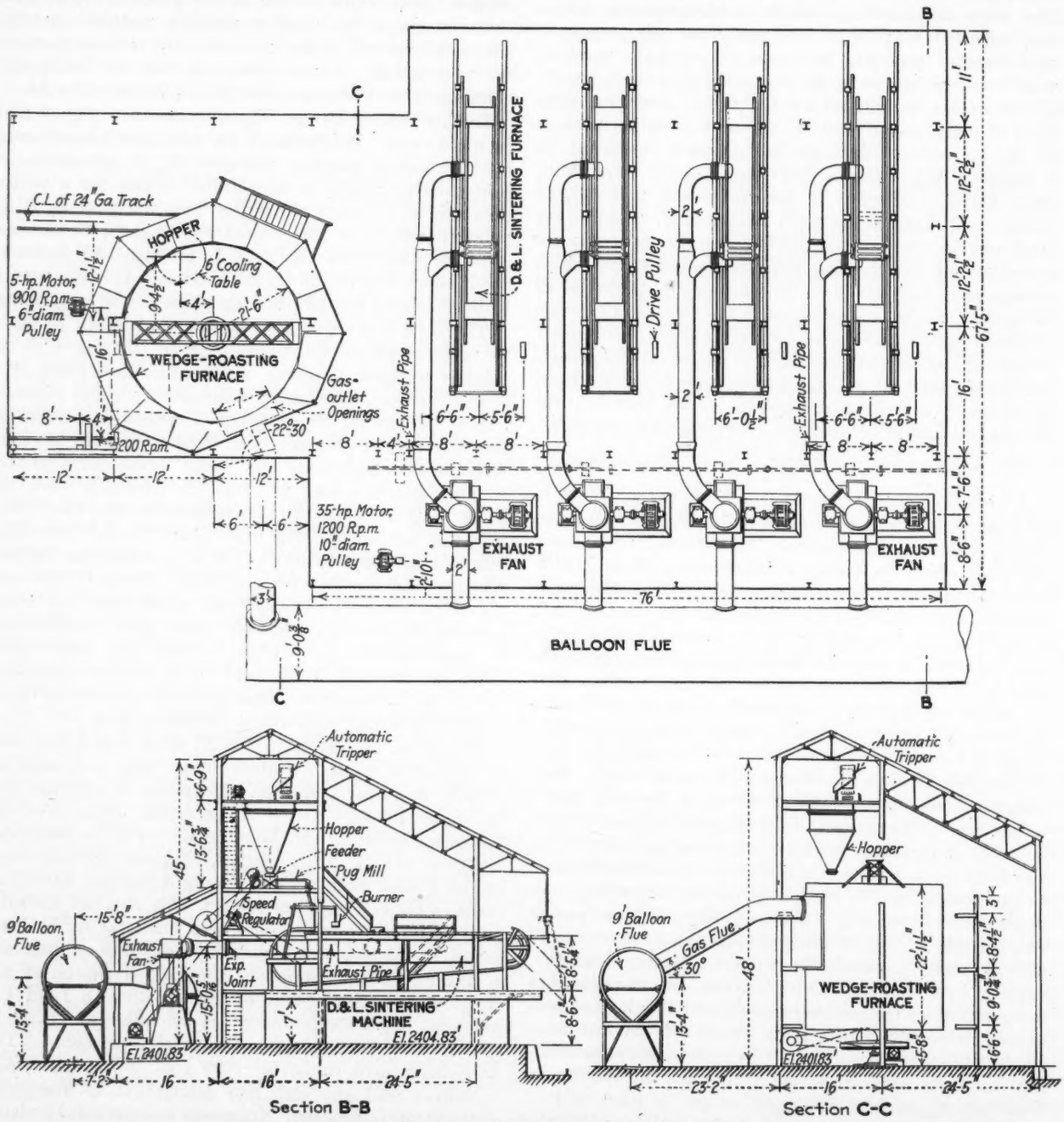


FIG. 3. PLAN AND TYPICAL CROSS-SECTIONS OF THE ROASTING-SINTERING PLANT OF THE BUNKER HILL SMELTERY NOW BEING ERECTED AT KELLOGG, IDAHO

kinds of conditions that the builders have been slow to depart materially from a design that has proved itself so satisfactory. Changes of small details have been made wherever a real improvement could be demonstrated, but in general the effect has been to standardize the parts and not to change for the mere sake of changing. The straight-line type (Type E) with pallets 42 in. wide and an effective hearth area 42x264 in. (77 sq.ft.) has been adhered to. This is rated at 100 tons per day, but is actually treating over 200 tons per day in some cases. The expense for repairs has probably not averaged much over 5c. per ton, and yet no machines of the present type can be said to have been worn out, though they have been in constant operation for over six years. A number of them have been through fires which they survived with little damage.

One important mechanical improvement has been the adoption of a heavily built double-inlet fan in place of the single-inlet fan previously used. The present standard type of fan has the same-sized impeller wheel as before (66 in.) with a center plate, or septum, extending from the hub to the periphery, each half being supplied by a separate gas inlet through the fan casing. The impeller is carried on a heavy shaft with outboard bearings and is preferably driven by direct-connected electric motor. The fan casing is made sectional, so that a portion of the casing is removable to facilitate the proper adjustment of the impeller in erection. This improved fan has contributed much to the increased capacity of the sintering unit and has shown itself distinctly economical in power. A separate fan should be provided for each machine.

The most striking feature in present practice is the great increase in tonnage that the machines have shown recently as the result of the growing understanding by metallurgists of the far-reaching effect of a proper regulation of the minutiae of the process, and a better knowledge of how to control the governing factors, as for instance, by regulating the composition of the mixtures, the percentage of moisture, the volume and degree of suction, the permeability as affected by the unformity of pressure in the ore mass as deposited on the grates of the machine, the segregation of the coarse and fine particles and finally the proper degree of ignition.

In several plants the machines are showing capacities as high as 150 and 200 tons per day, producing a satisfactory quality of sinter in one operation. As the tonnage is pushed above this figure, the quality of the product is apt to deteriorate and a certain amount of fines result, which strictly speaking, ought to be screened out and sent back to the machines.

Overburdening the Sintering Machines Intentionally

This procedure is deliberately followed in several large plants, where the machines are run at a capacity of about 250 tons per day, of which about 25 to 50 tons will be fines to be screened out and sent back to the charging bins, leaving a clean product of about 200 tons per machine per day of sinter for the blast furnaces. The fines consist of partly roasted ore and small pieces of friable sinter that desintegrates when the product is discharged. The favorable effect of a certain proportion of crushed sinter returned to a sintering charge has long been noted, and it has been frequently observed that instead of displacing other material, it will not only carry itself, but actually increase the capacity of the machine for new material.

Referring again to the so-called "double roasting" in which D. & L. machines are used for preroasting a charge relatively high in sulphur, a small amount of sinter will probably be produced in the first operation, which must be removed or crushed to small size before the preroasted product is charged back to the final sintering operation on another set of D. & L. machines, as this apparatus is peculiarly sensitive to the physical character of the material fed to it, and good results cannot be obtained if large lumps are mixed in with the otherwise fine charge. H. & H. pots are not so easily affected by coarse material in the mixture, and therefore it has been found convenient in those plants that are already equipped with H. & H. pots to use them for the finishing roast after having performed the first roast on the D. & L. machine. In the end nothing is saved by avoiding the intermediate crushing, because the huge cakes of H. & H. product require crushing before the material can be sent to the smelting furnaces, while the D. & L. sinter does not require crushing. As a mere matter of handling, the H. & H. plant equipped with overhead crane can meet this service most satisfactorily, as the D. & L. machine can discharge the preroasted ore directly into a pot bowl, which can then be moved by the crane to the blowing stand. Several plants are now using their H. & H. pots to good advantage in this way. Another large lead plant, which has used the D. & L. process for six years, is making extensive alterations to permit of carrying on both preroasting and finishing on the D. & L. machines, using a battery of 12 units.

It will be observed that there is a similarity in the two plans just described, the essential difference being based on the proportion of finished sinter that it is aimed to make in the first operation. The double roast will yield a product with residual sulphur as low as 2.5%, with most of it as sulphate, so that but little matte is made. In the single operation, 4% sulphur is about as low as can be reasonably expected in the sinter.

The Handling of the Materials

The lead smelter has never been able to take full advantage of the opportunities for economical handling made possible by the general introduction of hopper-bottomed railroad cars and locomotive cranes and grab buckets for handling materials in large bulk. The reason is that he is always confronted by the necessity of sampling his material with great care, as the entire commercial side of the business depends upon extremely accurate sampling of ores purchased and of metals sold. In spite of this handicap it has been found possible in many plants to effect considerable economy in the handling and sampling of ores on arrival at the plant by the adoption of such of these conveniences as could be made to fit the special conditions. For ores that are to be smelted direct, it is generally considered desirable to limit crushing to what is necessary for taking an accurate sample. Special unloading tracks, where the cars can be discharged by shoveling or dumping into hoppers underneath the track, have been found satisfactory and economical, whence the ore can be transported by belt to the sampling mill or other department of the plant. The Vezin sampler still holds its place as the most popular automatic sampler for smelting work.

For storing the ore previous to treatment, bins are generally used, supplemented sometimes by stockpiles from which the ore can be reclaimed by steam shovel or grab bucket with locomotive crane, loaded into cars and delivered to the bin nearer the smelting furnace. The making of huge ore beds with carefully stratified layers of different materials, as was once standard practice in the lead-smelting business, is not so frequent now, though small lots have to be bedded. The very ingenious ore-bedding system devised by Messiter was originally planned to meet the peculiarly exacting requirements of the lead smelter, but it has never been adopted in all its details at any plant smelting lead ores, though it has been extensively used in copper-smelting practice since the first one was built by me at Cananea in 1906. There has been a distinct tendency in the last few years to carry smaller ore stocks than was formerly the case, and moreover, a large proportion of the blast-furnace tonnage is now furnished by the roasting department, and some excellent devices have been developed for economically making up the roaster charge from separate ingredient bins. Hence there has not been so much need for a bedding system. One of these methods is to have a weighing hopper under each bin from which a larry car operated by an electric motor can take its charge when desired. Another way is to have a scale on the larry car itself and take from each bin the exact amount of each ingredient required. This is the basis of the admirable plan devised by L. D. Anderson, superintendent of the United States Smelting Co., Midvale, Utah, and which not only seems to meet most of the theoretical requirements of correct feeding, but combines a number of clever mechanical economies.[3]

Still another method, adapted especially for fine material, is that developed by Dwight & Lloyd in connection with their sintering plants. This improvement, which was worked out by Henry J. Stehli, of the Dwight & Lloyd staff, consists in having each ingredient bin provided with a slowly moving self-feeder, the belt forming the bottom of the bin and dragging out through an adjustable opening in the front of the bin a predetermined volume of material, which is discharged upon a collecting belt that carries it to the proper place for the subsequent operation. The discharge from these belt feeders can be accurately calibrated for each material; by weighing the actual amount delivered in a given time and by carefully adjusting the front gate, it is possible to get exactly the right amount required per minute of each ingredient, which is then delivered in stratified form on the collecting belt. Thus a minimum mixing is needed to deliver a thoroughly average and intimately mixed stream of ore to the next succeeding operation. Fig. 4 shows a view of a battery of storage bins equipped with this style of belt feeder, as installed in connection with the Dwight & Lloyd plant recently built at the Northport smelting works. The bins thus equipped represent a total storage capacity of 3,000 tons and can turn out easily 600 tons per day of accurately proportioned mixture for the sintering plant. One man per shift is all the labor required. As practically three-quarters of the blast-furnace charge at this plant consists of D. & L. sinter, it will be evident that the labor of weighing, mixing and handling the ingredients of the charge as ordinarily practiced has been largely eliminated by this plan. There are several successful installations of this kind that have been in steady operation for a number of years, so that the plan may be considered as having been thoroughly proved out.

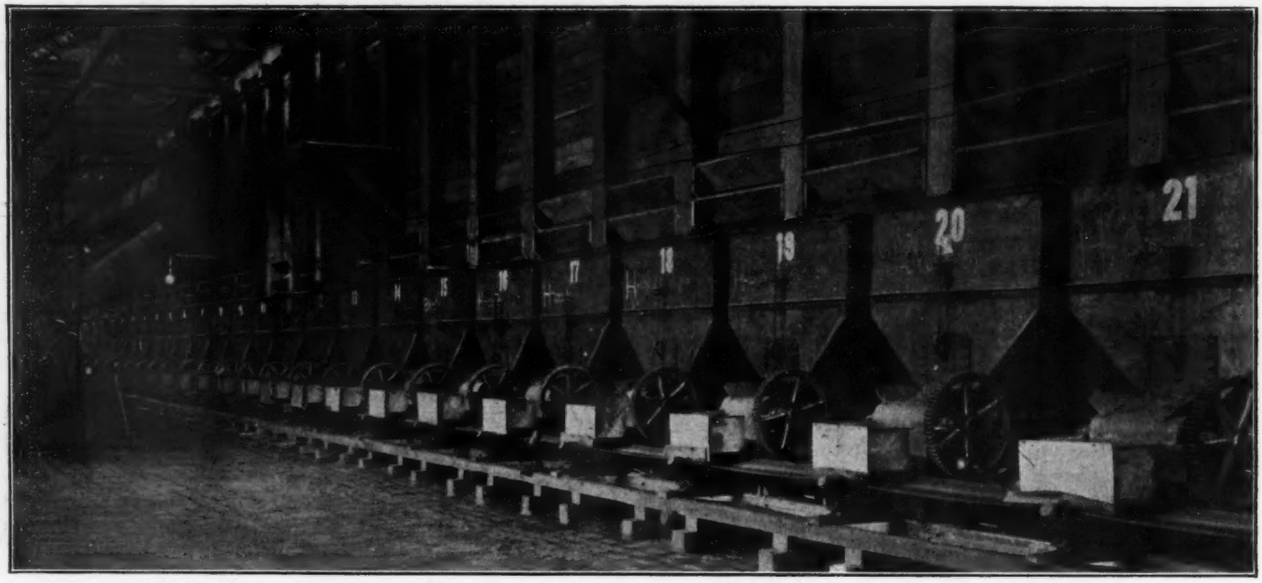


FIG. 4. AUTOMATIC SYSTEM OF PROPORTIONING THE CHARGE FOR D. & L. SINTERING PLANT AT NORTHPORT, WASH.

There seems to be no good reason why the same plan of continuous feeding cannot be used for making up charges for the blast furnace and delivering by conveyor directly to the furnace, substituting, of course, for the belt feeders, which are primarily adapted to fine material, a device capable of delivering a regular measured supply of lumpy material. The operations of the blast furnace would doubtless be favorably affected by the absolute uniformity of conditions that could thus be maintained.

As many plants are now making up almost the entire blast-furnace charge on the sintering machines, it would

[3]L. D. Anderson, "Eng. and Min. Journ.," May 20, 1916.

seem to be logical to go a little further and sinter all the charge except perhaps the limestone, and let the sintering machines deliver directly to a properly designed continuous-charging device on the furnaces. Some precautions would have to be observed, of course, to maintain the fundamental requirements of each apparatus, but there appears to be no reason why this cannot be worked out satisfactorily.

General Tendencies in Lead-Smelting Practice

Lead ores may be smelted with two distinct objects in view: (1) To use the lead as a collector of gold and silver in the ore charge, the metals to be afterward separated by the refining process; and (2) to extract the lead, primarily for its own sake. Most of the Western lead-smelting plants follow the first plan and smelt charges carrying 12 to 15% lead, making a relatively large proportion of slag. The Missouri plants start with a rich galena concentrate and aim to smelt this with a minimum amount of fluxes—just enough in fact, to take care of the residual gangue in the concentrates. They carry a percentage of lead on the charge as high as 45% and make the smallest possible quantity of slag—sometimes as low as 900 lb. per ton of original concentrates. No ores other than lead are available, and therefore the fluxes are barren of values, silica sand, oxide of iron and limestone being usually most available.

In the Northwest, where Idaho lead ore is comparatively plentiful, there has been a tendency recently to approach the Missouri practice and smelt principally for the sake of producing lead. This is the case at East Helena, Northport and, presumably, will be at the new Bunker Hill smelting works.

When one comes to regard the situation critically, one is forced to admit that it is a somewhat irrational procedure to spend money on expensive concentrating plants to remove the natural gangue of a lead ore and then mix the rich lead concentrates so obtained with other earthy substances for the sake of reducing them to metal. It seems as though the rich PbS concentrate should be regarded as a chemical substance rather than an ore, and logically there ought to be some better way to treat it than to use the same method that is especially adapted to the treatment of large tonnages of low-grade ore. I believe that such a method will be found in due time, but that it is not yet in sight.

Scotch Hearth Revived by Newnam's Development

The Scotch hearth has been largely used to treat the rich lead concentrates of Missouri, and at one time the Flintshire furnaces were also used. The unsanitary features of these processes, the large production of lead fumes difficult to recover and re-treat, and the fact that the "gray slags" from the hearths have to be put through the blast furnace with sufficient amount of flux to make the same amount of slag that would have been made in a direct smelting of the original concentrates have militated against the hearths. The dangerous nature of the occupation, the severity of the labor while exposed to heat and poisonous lead fumes, and the impossibility of getting men to stand it at all during the hottest months of summer did much to throw the decision in favor of the blast furnace. The Scotch hearth drove out the Flintshire furnace, and when the combination of sintering and blast furnace had almost driven out the Scotch hearth, a new element entered the problem in the recent development, at the Collinsville, Ill., plant of the St. Louis Smelting and Refining Co., of a modified Scotch hearth devised by W. E. Newnam[4] in which hand labor is largely dispensed with and much of the danger of lead poisoning eliminated. It is twice as long as the ordinary Scotch hearth and has nearly three times the capacity, using two men per shift. The device has already given a good account of itself and promises to save the Scotch hearth from extinction. Whether it can compete in the long run with blast-furnace smelting remains to be proved. It can probably do cheaper work than the blast furnace on concentrates carrying 70% Pb or over. A certain proportion of the output of the Missouri mills will come under this category and be amenable to treatment by the Newnam hearth, but the bulk of the tonnage is below 65% Pb and must go to the blast furnaces.

The Empire Zinc Mill at Hanover, N. M.

The Hanover mine is in Grant County, New Mexico, just over the ridge from the Chino steam-shovel pits at Santa Rita. Hanover lies at an altitude of 6,200 ft. The mines were first opened up by the Mineral Point Zinc Co.

HANOVER MILL OF EMPIRE ZINC CO.

under the supervision of W. N. Swancoat in the early 90's. A large tonnage of high-grade zinc carbonate and some sulphide was mined and shipped. The property was then idle for several years. In 1908 work was again started, and production has been fairly continuous to the present time.

The mineralized area consists of sedimentary series, largely limestones, of Carboniferous age, intruded by a large mass of granodiorite porphyry. This intrusion was followed by intense metamorphism resulting in the formation of such characteristic contact minerals as garnet, epidote, magnetite, hedenbergite, etc. At the same time the zinc sulphide was formed with pyrite and other sulphide minerals. In all cases the ore occurs near the contact. Part of the zinc ore was later oxidized to carbonate, which has been the principal commercial ore to the present time.

[4] "The Newnam Hearth," by W. E. Newnam, Bull. A. I. M. E., October, 1915.

Oxidized zinc ores, mainly carbonates, have been mined from numerous openings along the contact, but the main workings are in the vicinity of the Nason Tunnel, approximately one-quarter of a mile northwest of the mill on the Buck Horn Gulch. Sulphide ores are being mined here also. In the Thunderbolt shaft, about one mile east of the mill, a considerable tonnage of sulphide ore has also been developed.

The mill, designed by L. G. Rowand, was started in June, 1916. It has a crushing capacity of 300 tons and a separating capacity of 100 tons per 24-hr. day. The ore is a hard, dense sulphide with contact rock and limestone carrying sphalerite, pyrite, galena and other sulphides in small amounts. Practically all the minerals are more or less magnetic, with the exception of the limestone and galena. The feed is closely sized, giving 8 sizes between 10-mesh and 150-mesh. Practically all material through 150-mesh is removed by the dust separator.

AVERAGE MILL RESULTS ON ROWAND WETHERILL MAGNETIC SEPARATORS

	% of Feed	Approximate Assays Zn	Pb	Fe	Ins.
Feed	100	18	0.2	6	39
Pole 1, 2 c.o., 3 c.o.	44	5	tr.	8	51
Pole 2 and 3 (part)	9	10	0.1	5	46
Pole 3 (part) and 4, concentrate	24	40	0.1	..	..
Pole 5 and 6, concentrate	6	51	0.1	..	..
Tails	4	10	12	16	23
Dust	11	20	0.1	4	34
Loss	2	..	...	..	..

Certain of the products are being stored for retreatment. Average recovery of zinc in concentrate, 67%.

Separator details: Speed of belt, 50 ft. per min.; speed of take-off belts varies from 940 ft. per min. on the highly magnetic material to 310 ft. on the lowly magnetic; power required for mill, about 110 hp.; power (d.c.) required for magnets, about 40 h.p.

Power is generated by a 250 h.p. Snow internal-combustion oil engine, using crude oil of 28° to 30° gravity. Consumption of fuel oil averages about ½ lb. per hp.-hr. A.-c. and d.-c. generators, each rated at 75 kw., are driven by the oil engine and furnish the operative power. The power plant is a delight—cool, clean and quiet; no pulsations or explosions, no dirty coal or smoky boilers.

The property is in charge of C. T. Brown, district manager and C. A. Schmidt, his assistant. K. A. Strand is superintendent.

Reclaiming Junk Metal

In a paper presented at the annual meeting of the American Institute of Metals[1], the handling of waste at the Hawthorne Works of the Western Electric Co. is described. The monthly averages of scrap metal are: Brass, 100 tons; copper, 180 tons (125 from cable, rubber and insulating shops); german silver, 17.5 tons; iron and steel, 89 tons; solder skimmings, 4 tons; lead, 833 tons.

Sheet metal from which special forms have been punched is compressed into bales with other large scrap pieces. Small chips and metal shavings are freed from dust and dirt by a mechanical sifter, and the iron and steel separated from brass and the like by a magnetic separator similar to the Ball-Norton type.

Junked cable is heated in gas ovens until the lead is melted and the insulation burned off. The lead is run into a furnace, which separates the ash and dross from it by gravity, and then cast into pigs for sale to refiners. The copper wire remaining in the ovens is compressed into brick form by means of a hydraulic press.

[1]"How a Large Manufacturing Company Disposes of Its Old Metal," by J. H. Bateman, Sept. 11-15, 1916.

Inspiration Operations in August, 1916

The ore at Inspiration occurs as disseminated chalcocite in silicified schist and granite porphyry, approximately 90% being in schist. The orebody of which the Inspiration holdings are a part extends from its eastern limits in Miami Co.'s ground to its western limits in the Inspiration-Live Oak ground, a distance of 9,700 ft. The ore is continuous for this distance, except where the Keystone ore is parted from the Inspiration ore for a horizontal distance of 1,100 ft., owing to the movement along the incline of the Bulldog Fault. The ore varies in width in the Inspiration ground from 200 to 1,600 ft. and has an average vertical dimension of approximately 150 ft.

Previous to the beginning of stoping in July, 1915, the ore had been developed by 29⅓ mi. of churn-drill holes and opened up by underground work as follows: 1.2 mi. shafts; 7.7 mi. haulageways; 21.1 mi. ordinary-sized drifts; 21.2 mi. main raises; 2.5 mi. finger raises; making a total of 53.7 mi.

The mining system consists of undercutting and thus caving the ore, which is then drawn off through a system of inclined raises to the haulageways below. It is estimated that for each 1,000 tons of ore mined there will have to be driven 13 ft. of ordinary-sized drift, 20 ft. of main raises and 1.4 ft. of haulageways, making a charge for this account of approximately $0.20 per ton of ore mined.

MILL STATISTICS, AUGUST, 1916

Dry tons milled		498,270
Tons per day		16,073
Per cent. copper in feed, total		1.564
Per cent. copper in feed, oxidized		0.392
Per cent. copper in feed, sulphide		1.172
Per cent. copper in concentrates		30.22
Per cent. solubles in concentrates		31.30
Per cent. moisture in filtered concentrates		17.67
Per cent. copper in tailings, total		0.417
Per cent. copper in tailings, oxidized		0.325
Per cent. copper in tailings, sulphide		0.092
Per cent. copper recovered		74.36
Per cent. copper recovered, oxides		20.00
Per cent. copper recovered, sulphides		92.44
Kw.-hr. per ton milled (includes coarse crushing, but does not include pumping new water		16.07
Water used per ton ore, total gal.		1,145
Water used per ton ore:		
Reclaimed in tanks at foot of mill	249	
Reclaimed from ponds	514	
New water from Kiser pump station	382	
	1,145	
Average tonnage ore ground per Marcy mill in 24 hr.		475
Flotation agents, lb. per ton ore (coal tar 1.12 lb., oils 0.19 lb.)		1.31

For the five-months' period ending with August, there was mined 18.1 tons for each shift's work above and

DETAILS OF SCREEN ANALYSIS

	Feed to Ball Mills	Producer
On 1.5-in.	17.7	....
On 1-in.	16.5	....
On ⅜-in.	24.7	....
On 3-mesh	7.3	....
On 6-mesh	7.7	....
On 8-mesh	2.2	....
On 14-mesh	4.8	....
On 28-mesh	3.6	....
On 48-mesh	2.9	2.9
On 65-mesh	....	7.9
On 100-mesh	2.3	12.6
On 150-mesh	....	12.6
On 200-mesh	1.5	5.8
Through 200-mesh	8.8	58.2
	100.0	100.0

The kw.-hr. required per ton ore in coarse grinding, conveying and sampling	0.409
The number of kw.-hr. required per ton ore in fine grinding in Marcy ball mills, divided into the following: Power for conveyor, Dorr classifier and cranes, 0.18; power for Marcy ball mills, 9.68	9.86
Total power for crushing and fine grinding, kw.-hr.	10,269
Steel ball (chrome) consumption per ton ore ground, lb.	1.79
Average tonnage per ball mill for 24 hr. in August	425
The per cent. of product stopping on 48-mesh screen	3.1

below surface properly chargeable to the mining department. The statistics for milling operation in August are given in the accompanying table.

The mine ore is crushed first in gyratory crushers having a maximum opening for discharge of 3¼ in. This product passes through Symons disk grinders having a discharge opening of 1½ in. This product is finished in Marcy ball mills at the concentrator as per accompanying table.

In the flotation department there are four sections equipped with Callow machines, 13 with Inspiration machines and one with Minerals Separation machine—Hebbard type (injects air under stirring paddles).

FLOTATION POWER REQUIREMENTS

Power Used:	Pneumatic Flotation Machines	Minerals Separation Machine	Total
Returning cleaner machine tails to primary flotation machine.	118,240	7,000	.....
For crane over flotation floor...	450	70	.....
For driving turbo-blowers and Root blowers	1,311,800	10,980	.....
For pump returning slime overflow drag-belt tanks for reflotation	13,440	.....	.....
For motors driving Minerals Separation Machines	.....	114,690	.....
	1,443,930	132,740	1,576,670
Tons ore treated.....	472,242	26,028	498,270
Kw.-hr. used per ton ore in flotation	3.06	5.1	3.16

The flotation oil consumption per ton of ore treated is shown by the following table:

OIL CONSUMPTION

Coal tar	1.1216
Coal tar creosote.....	0.1333
Wood creosote (Cleveland Cliffs).....	0.0023
No. 80 oil (Pensacola).....	0.0058
No. 6-11 oil (Oregon).....	0.0204
No. 880 oil (Yaryan).....	0.0072
No. 9 oil (General Naval).....	0.0205
	1.3111

Power used in August was as follows:

AUGUST POWER REQUIREMENTS

	Kw.-Hr.
For air compressors	32,800
For vacuum pumps	48,400
For Dorr thickeners	4,270
For elevators	13,220
For filters	3,510
For concentrate conveyor	6,910
Total	109,110

A total of 19,106 tons concentrates were filtered at a power cost of 5.71 kw.-hr. per ton.

POWER CONSUMPTION IN AUGUST, 1916

	Kw.-Hr.	Kw.-Hr. per Ton
Mining—Tons mined, 493,900:		
Power for machine drills and vent, 100 lb. air	651,300	1.310
Power for air haulage, 1,000 lb. air.....	185,790*	0.376
Power for ore hoisting	358,320	0.725
Power for lights	9,300	0.019
Power for miscellaneous mine department uses	59,760	0.121
	1,264,470	2.56
Coarse crushing, conveying and sampling, tons treated 493,900.....	201,000	0.409
Concentrator—fine crushing, tons treated, 498,270	4,914,980	9.86
Flotation	1,576,670	3.16
Tables:		
Power for tables—Kw.-hr., 182,760; tons treated, 245,790; kw.-hr. per ton, 0.74; power for drag belt classifiers separating sands for concentration—Kw.-hr., 20,430; tons treated, 469,274; kw.-hr. per ton, 0.04.....	203,190	0.41
Filters—Concentrates, kw.-hr. per ton, 5.71	109,110	0.22
Tailings disposal—Motors for Dorr dewatering tanks	4,980	0.01
Water reclamation — Repumping water from tailings ponds.....	941,365	1.89
Sundry power—Machine and carpenter shops, incline hoists, etc.....	30,950	0.06
Lights	25,170	0.05
Pumping new water..... 655,485		
Lights 1,320		
	656,805	1.32
Crushing rock for concrete.....	1,000	...
Lights for offices, dormitory, dwellings, etc.	1,410	...
Total kw.-hr.	9,931,100	19.95

*Average mine haul, 0.475 mile; kw.-hr. per ton-mile, 0.796.

The flotation concentrates average 38.11%. The air consumption is approximately 75,000 cu.ft. In filtering the concentrates the stream of water carrying concentrates from the mill goes first to Dorr thickening tanks and then to six Oliver filters, 11 ft. 6 in. diam., 12 ft. long. The stream to the Dorr tanks contains 90% water; the feed from tanks to filters contains 42% water; while the filtered concentrates contain 17.67% water. The settling of concentrates is done in five 60-ft. and three 80-ft. diam. tanks having a total area of 29,217 sq.ft.

The power required for mining was 2.56 kw.-hr. per ton; for milling, 16.07 kw.-hr. per ton, and for pumping new water, 1.32 kw.-hr. per ton, making a total of 19.95 kw.-hr. per ton. The average power requirement in August was 0.83 kw. per ton of daily capacity.

Efficiency of Rope Drives

By William Hirst

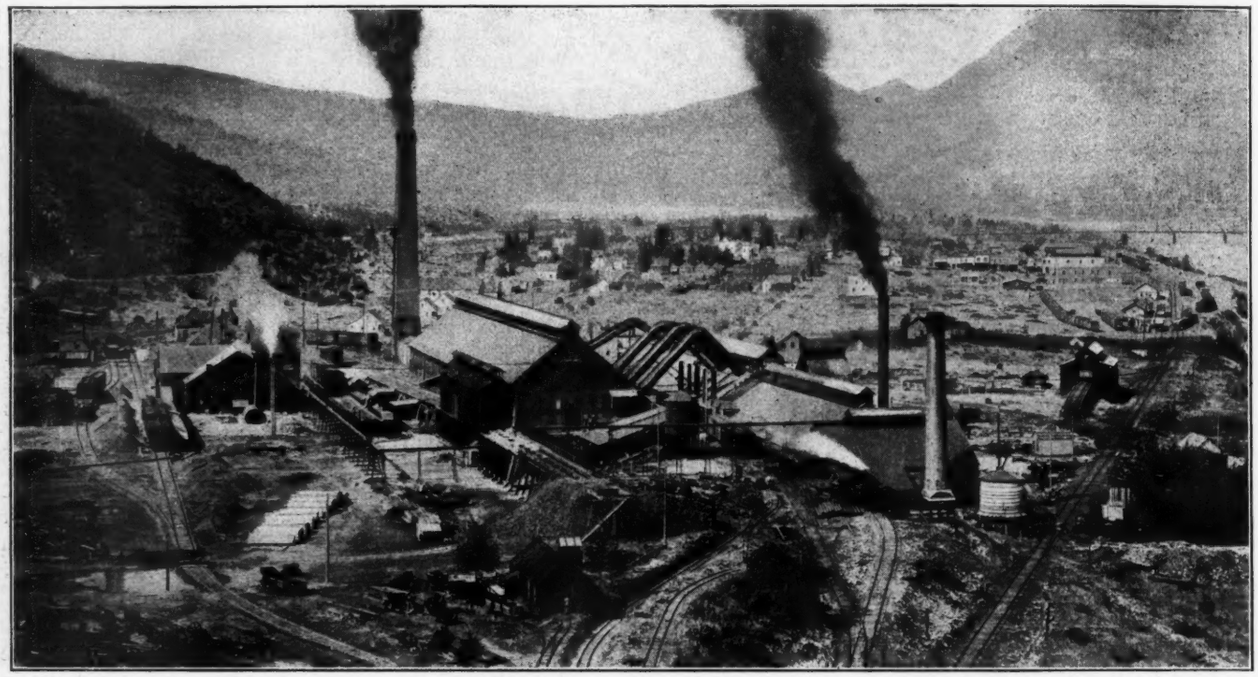
To one who has not had experience with rope drives it may be difficult to understand why a single strand of rope will show a higher efficiency than two or more, says *Power*. The natural inference is that if one rope has an efficiency of 97 per cent., a drive of ten should have the same.

To have each individual rope pull exactly its share of the load each groove must be exactly the same pitch-diameter and shape. Furthermore, the ropes themselves must be of the same diameter and tension when running, so that each will rest at the same depth in the groove. If this condition could be realized, then the same efficiency could be attained with a number of ropes side by side as with one, but this degree of perfection is never realized; hence the actual efficiency depends largely if not altogether on the degree of accuracy in the sheaves and uniformity in the size and tension of the ropes. No matter how small the difference in the pitch diameter may be, the rope or the groove having the greatest diameter in the driving sheave, or the one having the smallest in the driven sheave, will pull the hardest. Assuming this difference to be 0.01 in., it will be 0.0314 in the circumference and in 100 revolutions the rope in one of these grooves would have drawn ahead of the others more than 3 in. and taken more than its share of the load; therefore, this rope or some other must slip. In most rope drives some of the ropes are slack on the pulling side and they can be heard creeping in the grooves. This accounts for the relatively low efficiency of the rope drive.

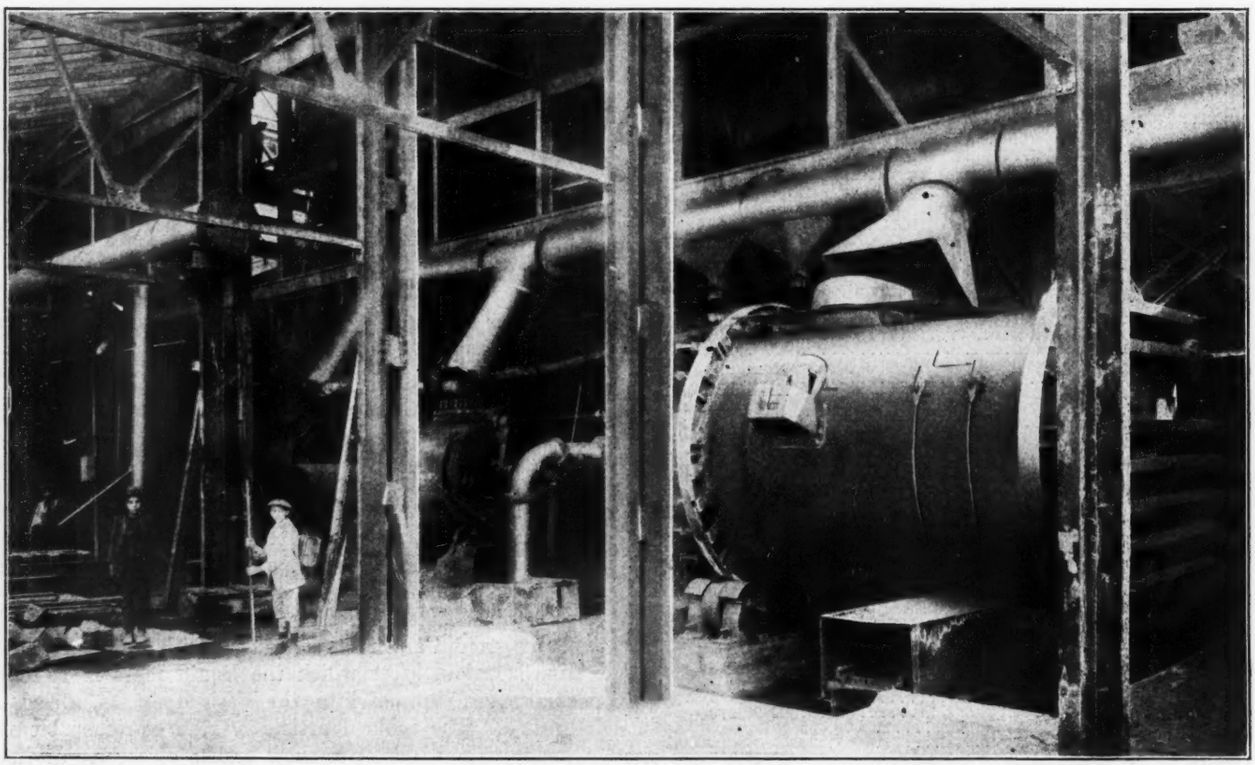
Refractory Vessels from Rare Earths

A recent German patent (287,554, Nov. 29, 1913), according to "Chemical Abstracts," deals with the manufacture of refractory shapes from zirconium dioxide, thorium dioxide, or both, or with various of the rare earths. The mixture is subjected to high mechanical pressure. After relieving the pressure the product is finely ground and then stirred up with water or an alkaline solution, after which the liquid mass is poured in the usual manner into the desired forms, dried and burned. The molded article is readily removable from the form and does not show cracks either on drying or burning. The vessels are claimed to be tight and sufficiently strong to resist fracture when thrown upon a hard floor.

Photographs from the Field

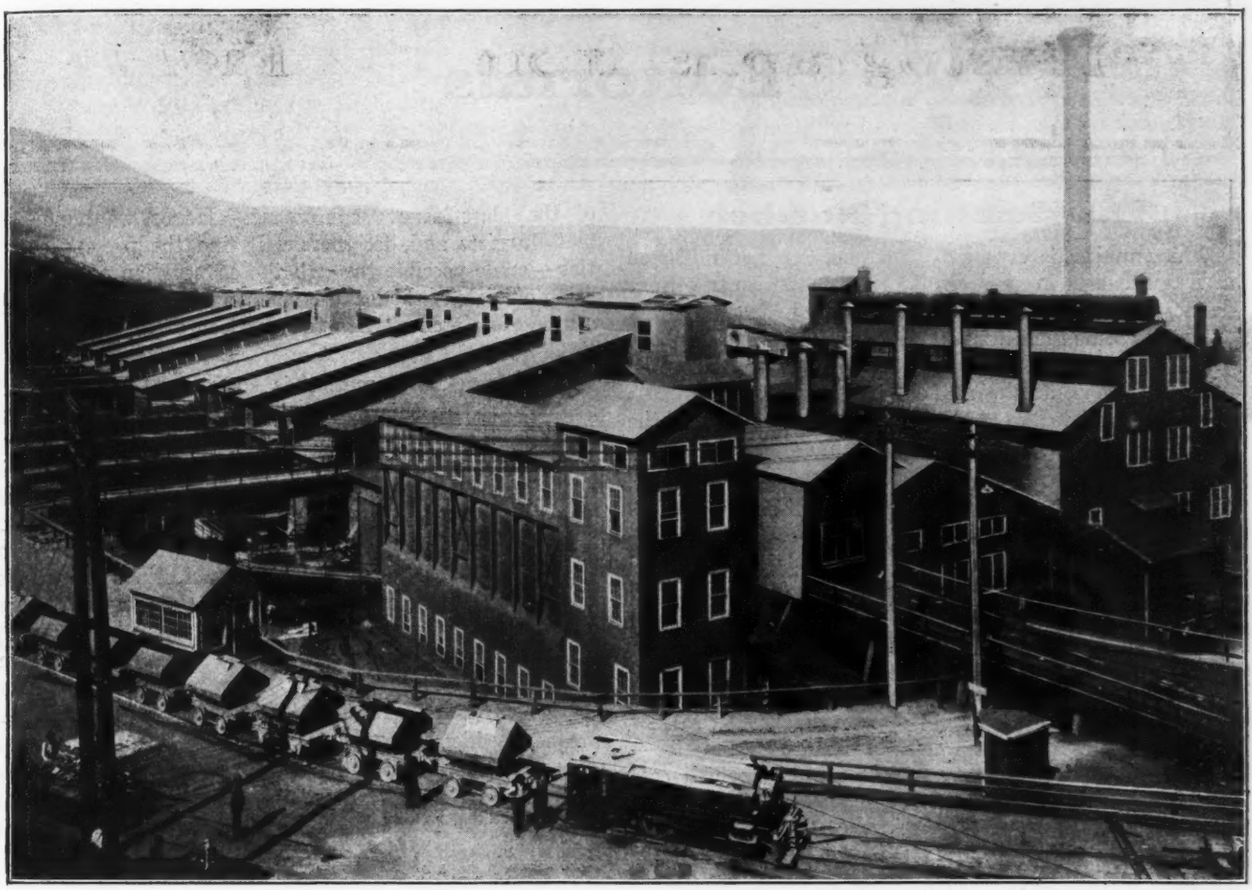


NORTHPORT SMELTING AND REFINING CO.'S PLANT AT NORTHPORT, WASH.



A SHORT PIERCE-SMITH BASIC-LINED COPPER-CONVERTER IN A CHILEAN SMELTERY

The above shell, 10 ft. diam. by 14 ft. 7 in. long, is in the Naltagua plant in central Chile. A number of these small units have been installed in foreign countries but none is in use in North America where the standard size is 10x25 ft., though shells 37 ft. 2 in. in length have been used.



REVERBERATORY-SMELTING AND COAL-PULVERIZING DEPARTMENTS AT ANACONDA, MONT.

THE 20-FT. GREAT FALLS TYPE CONVERTERS AT THE WASHOE REDUCTION WORKS, ANACONDA, MONT.

Editorials

This Smelting Number

This number is especially for smelters, not mill-men or metallurgists in general. Therefore the contributions do not include anything pertaining to hydrometallurgy except for some incidental references. The scope has been limited so closely to the special field that not even is the important work of the refiners included.

With regard to the work of the smelters, however, the view has been broad, taking in copper smelting, lead smelting, zinc smelting and quicksilver smelting. All these subjects are treated by authoritative hands. Indeed, the collection of contributions in this number is noteworthy. The names of Dwight, Laist, Landers, Capron, Kuzell and Magnus speak for themselves. The articles by Mr. Laist reviewing improvements at Anaconda, which name is becoming a synonym for leadership in the art of copper smelting, and by Mr. Dwight on lead smelting are especially remarkable and valuable.

In the subject of zinc smelting are described two new plants that are the last words in American practice—Donora, exemplifying a remarkable plant in which coal is the fuel, and the works at Van Buren, Ark., of the Arkansas Zinc and Smelting Co., which is the latest of constructions for natural-gas firing. The former was designed by Nicholas L. Heinz, the latter by George E. Nicholson, both of them experienced and successful zinc-smelting builders. In both cases extraordinary records in speed of construction were made.

Both Mr. Dwight and Mr. Ingalls in their contributions have been uncommonly free in their expressions of opinion. This was the result of a conspiracy incited by Dr. Ricketts, which however, fell down through his own delinquency. Ricketts said, not long ago:

"Let's have some articles in which we do not dwell too much on realities, but speculate on some of the things that we think ought to be and may be. Never mind if we are wrong in a lot of our ideas, we can afford to be, and if we can get some of the younger men working on new lines, that will be worth while."

"That's a good idea, Ricketts," we said. "Start it, yourself."

"All right, I will," said he. But he had to go to Arizona to run the very successful meeting of the American Institute of Mining Engineers and did not come to time, leaving his fellow conspirators a solitary pair. So all we could do was to publish his picture, but we feel sure that our readers will hear from Dr. Ricketts later.

Tuyeres for Copper and Lead Blast Furnaces

Attention is directed to the two pages, 640 and 641, in this issue of the *Journal*, presenting drawings of the leading types of tuyere connections used in important North American smelting works. Occasionally there have been tuyere drawings published, but we do not recall any adequate and convenient collection presenting this detail of the blast-furnace equipment. Hence we hope that metallurgists and designers will find the present collection—made possible through the coöperation of the operating officials of the leading smelting works—a convenient source of reference when the question of tuyere design is to be decided.

While smelting practice is in general respects well standardized in this country, both as to equipment and practice, there is probably no single feature of smelting equipment in which more variety of design exists than in the tuyere connections for copper and lead blast furnaces. This is the more remarkable because the requirements of the service are practically identical. In other features of the blast furnace there exist divergencies in different districts in such matters as bosh, feeding arrangement, etc., but these are usually inherent upon different physical conditions of the ore, or of plant arrangement, whereas the tuyeres and tuyere boxes perform practically the same service at each furnace and conditions of maintenance are nearly identical.

It is proper, however, to regard the copper and lead furnaces in two different classes; certain differences in practice make it necessary to take greater precaution in lead operations against explosion of furnace gases, after back-drafting; also in lead practice the tuyeres are punched only as specially needed. In copper practice it has been customary at most plants to punch tuyeres regularly on each shift, though of late years there has been a tendency to punch only when needed. In the main the conditions at the copper works have varied only in the frequency of slagging or of punching. These are differences in degree only, but have been responsible at certain plants for the redesigning of tuyere boxes, particularly where frequent slagging involved the digging out of tuyeres and increased labor cost, or reduced attention on the part of the crew to other details of the furnace operation. Air leakage was an important matter that only lately received efficient attention.

Different plants have to a certain extent different problems, but the variety that has developed in tuyere design was largely the result of individual action at the different works when furnaces were being rebuilt or when leaking or slagging tuyeres accelerated the redesigning of this feature alone. Generally speaking, little attempt was made to take advantage of the improvements made at other works, though one enterprising manufacturer of mining machinery has appreciated the possibilities of an eclectic equipment that would incorporate such of the local improvements as were adapted to general smelting conditions. This is of considerable advantage to the industry, as new smelting works may now start with an improved tuyere instead of beginning with the old-style slightly-cheaper-in-first-cost tuyere that soon leaked air and probably filled with slag on the first day of service—and continued its inefficient career until the metallurgist awakened to the expense of compressed air and misdirected labor.

Many plants have simply pursued a policy of *laissez faire* in regard to the use of their old-style "expensive" tuyere connections; the metallurgist has been busy with larger problems, and perhaps if he had asked for more efficient tuyere boxes, he would have been refused so long as the original ones were not all broken. Another cause for the survival of the stereotyped tuyere box was that at some of the larger works, all construction was in the hands of the engineering department, the headquarters of which were often away from the plant; or it might have been that the engineering and operating departments were not in complete harmony. At any rate there was no coöperation between the two departments; when an addition was made, the engineers, not being familiar with the operating difficulties, often designed "good castings," but did not improve the operation of the new section of the plant. This condition happily has to a great extent disappeared, though it is still to be guarded against in some large organizations.

Minerals Separation vs. Miami

A decision in the case of Minerals Separation, Ltd., vs. Miami Copper Co. was rendered by Judge Bradford of the United States District Court for Delaware, at Wilmington, Sept. 29, 1916. Before considering this decision it will be helpful to explain the position of the court that makes it.

The first case involving the flotation patents in the United States was brought by Minerals Separation vs. Hyde in the United States District Court for Montana, and a decision in favor of the plaintiff was rendered by Judge Bourquin at Butte. Hyde appealed, and from the United States Circuit Court of Appeals, sitting in San Francisco, obtained the famous reversal of Judge Bourquin's opinion and the new judgment that the Minerals Separation patents were quite invalid.

Minerals Separation being determined to get the case before the United States Supreme Court, which ordinarily does not hear patent cases at all, had two courses open to it; namely, to take the chance of reaching the Supreme Court through a writ of *a certiorari* or to institute a new suit in another district with the hope of reaching the Supreme Court through conflicting decisions. It took both of them. The Supreme Court granted the writ of *a certiorari,* thus insuring a hearing, but nevertheless Minerals Separation stuck to its suit against Miami in the Delaware district. The decision of Judge Bradford is analogous to that of Judge Bourquin. If the case be now appealed and if another Circuit Court of Appeals upholds Judge Bradford and conflicts with the decision rendered in San Francisco, the case would be bound to go to the Supreme Court.

Judge Bradford, in a lengthy, argumentative decision, upholds the main Minerals Separation patents on points that may be stated simply. In U. S. Patent 835,120, granted Nov. 6, 1906, to Sulman, Kirkpatrick and Ballot, claims 1 and 12 specify the use of "a fraction of one per cent. of oil" and are held to be valid. Claim 9 specifies "a small quantity of oil," which is regarded as so indefinite as to render the claim void. According to this decision anybody using 0.99% of oil would infringe claims 1 and 12; the use of 1.01% would not. Everson, Froment and all the other previous experimenters in this field used more than 1% of oil, and their processes are pronounced uncommercial and nonanticipatory.

This is about as contradictory of the San Francisco decision as anything could be. That decision is not mentioned by Judge Bradford, but everything held by the court there to anticipate the Minerals Separation patents has been distinctly held by him to do no such thing, and practically all the conclusions of the San Francisco court are inferentially to be regarded as erroneous in the opinion of Judge Bradford. His avoidance of any specific reference is to be ascribed to his knowledge that the decision of the San Francisco Court is before the Supreme Court for review. Indeed, that case is probably to be argued during the week commencing Oct. 30.

The rapid growth of the zinc-smelting industry in Japan has been one of the interesting features of the recent era of high prices. A large tonnage of Australian ore is being taken by Japanese smelters, and there are reports of more smelteries to be erected in Japan. It was not to be expected that the Japanese would be inactive in such a situation as has existed of late.

We suggest special attention to the article by Mr. Pigott, which appears in this number, for it describes what is really a remarkable change in lead blast-furnace smelting practice during the last two years; namely, the elimination of slag-shell resmelting. This may sound like heresy to many old lead metallurgists who ever since they were born—into metallurgy—have seen slag shells saved, broken and resmelted. The innovation has saved thousands of dollars to the several lead smelters who are practicing it.

As we forecasted last week, the general sympathy strike in New York proved to be a fiasco. A considerable number of Jewish citizens ceased work, it being a holiday season, and so did a few brewers, whose defection caused no noticeable suffering among the population, but on Monday, Oct. 2, the police reported only 400 of all trades on strike. Monday brought a real trouble, however, in the cutting off of a large part of New York's milk supply by a conspiracy of farmers (!) who carried out their threat to do that thing if they could not get the price they wanted for their product. Verily, we are becoming a lawless people. If things do not suit any organized group, hold up everybody! Is this a result of exempting labor unions and farmers from the Sherman law?

The American Institute of Mining Engineers has just completed in Arizona the most successful meeting of its history. The scenario was the best there could be. Montana and Utah have great and interesting mining and metallurgical centers, but Arizona has more of them and more diversification. There was, moreover, an old-time Institute flavor in the experiences of traveling from place to place and enjoying repetitions of the kindly hospitality of good men and women who tried to outdo one another. The *Journal* sent two members of its staff—Lieutenant Barbour, who obtained leave of absence from his regiment and Mr. Hall—to represent it at the meeting and report. They have turned in a wealth of material which ought to have gone in this number, but unfortunately this issue had been scheduled three months ago and there could be no deviation from the plan. A full acount of the Institute meeting will be given next week.

PERSONALS

Otis D. Welsch has changed his address to Berlin, Nev., from Tonopah, Nev.

C. Mason Farnham, chief geologist for the Cerro de Pasco Mining Co. is in New York.

J. B. Tyrrell, of Toronto, is making an examination of the Rice Lake gold field, Manitoba.

A. F. Peterson has moved to 435 N. Park, Madison, Wis., from 217 Aurora Loc., Ironwood, Mich.

G. D. Van Arsdale is in Douglas and Bisbee in connection with the Copper Queen leaching and flotation experiments.

August Heckscher, a director of the Eastern Steel Co., is on the board of directors of the Alaska Mines Corporation.

John Seward is examining mining properties in Ontario and Quebec and will return to New York the middle of October.

Albert H. Morrell, formerly assistant engineer of the Central Chile Copper Co., has been recently made mine superintendent.

Montrose L. Lee, formerly with the Uruguayan Geological Survey, has returned to the United States and has gone west on an examination trip.

James Gayley, formerly vice-president of the United States Steel Corporation, is the president of the newly-organized Alaska Mines Corporation.

M. C. H. Little has resigned his position as manager of the St. Anthony mine, Sturgeon Lake, Ont., Canada, having volunteered for Overseas Service.

Homer Neal, formerly with the Braden Copper Co., has recently been appointed engineer in charge of the Central Chile Copper Co. mines in Tambillos.

E. H. Gary, chairman of the United States Steel Corporation, who for several months past has been touring Japan and the Far East, arrived at Seattle, Sept. 23.

Philip Gleason, formerly with the Braden Copper Co., is metallurgical chemist and assistant superintendent of the smelter of the Central Chile Copper Co.

Prof. Charles S. Parsons of the Bureau of Mines sailed for Europe Oct. 5, to make an extensive study abroad preliminary to the establishment of the proposed government nitrate plant.

Norman M. Shand wishes to deny the report, published in the technical press, that he has been appointed assistant general manager of The Sons of Gwalia Mine, in Western Australia.

Prof. Francis Church Lincoln, director of the Mackay School of Mines, University of Nevada, Reno, Nev., has recently returned after spending the summer in mining work in Bolivia and Peru.

H. M. Wolfin, of the Bureau of Mines, is enjoying a vacation at his home in Redlands, Calif. He is expecting to return to Pittsburgh by way of San Francisco, Seattle, Butte, Chicago and Detroit.

J. Volney Lewis has just returned to the East from an extended professional trip through the western mining states, British Columbia, and Alaska, in the interest of a development company.

P. A. Mosman, making one of his semi-occasional tours of inspection of the various A. S. & R. smelting plants, accompanied the A. I. M. E. excursion from El Paso to Douglas, Bisbee, Globe and Miami and then returned to El Paso.

D. W. Brunton, G. H. Clevenger, Walter Douglas, Karl Eilers, Sidney J. Jennings, Seeley W. Mudd, E. P. Mathewson, J. J. Ormsbee, O. C. Ralston, Bradley Stoughton, and **B. B. Thayer** were among those who took the recent trip of the A. I. M. E. to the Southwest for the Arizona meeting.

W. H. Bischoff, superintendent of open-hearth department No. 2 of the Saucon plant of the Bethlehem Steel Co., has resigned to become superintendent of coke ovens, blast furnaces and open hearths for the Dominion Iron and Steel Co., Sydney, Nova Scotia. Mr. Bischoff had been with the Bethlehem company for 24 years.

Charles Camsell, of the Canadian Geological Survey, has returned from an extended tour of investigation in the West and reports discoveries of crude oil on the North Shore of Great Slave Lake. He found drilling for oil in progress at the Thomas well at Peace River chutes and at the McArthur well near the town of Peace River.

OBITUARY

Samuel Powell Stackhouse Ellis, aged 66, died, Sept. 19, in his home, 5716 Rippey St., Philadelphia. He was born in Philadelphia, Aug. 6, 1850, and was educated in Philadelphia High School. In 1870 he went to Johnstown as private secretary to the late D. J. Morrell, of the Cambria Iron Co., and was connected with that company for 19 years as assistant to the general manager, when he resigned to accept the position of sales manager for the Pittsburgh district of the Lorain Steel Co. He was with the Lorain company 23 years. His widow, Mrs. Acsa Frazer Ellis, and four children, Dr. Charles J., Misses Sara F. and Catherine Ellis, and Mrs James H. Kennon, survive.

SOCIETIES

National Safety Council will hold its fifth annual meeting at the Hotel Statler, Detroit, Mich., from Oct. 17 to 20 inclusive. Iron and steel foundry sectional meetings will be a feature of this congress.

The American Society of Mechanical Engineers, New York section, will hold a technical session on October 10th at 8.15 p.m., in its rooms at 29 West 39th St. Dr. Charles L. Reese, of the du Pont company will give an illustrated lecture on explosives with special attention to their use for industrial purposes.

NEW PATENTS

United States patent specifications listed below may be obtained from the "Engineering and Mining Journal" at 25c. each. British patents are supplied at 40c. each.

AMALGAMATOR. Erastus B. Bennett, Denver, Colo. (U. S. No. 1,198,408; Sept. 19, 1916.)

ALKALI-METAL COMPOUNDS, Process for the Manufacture of. Edgar Arthur Ashcroft, London, England. (U. S. No. 1,197,329; Sept. 5, 1916.)

ALLOYS—Process of Making Brass and Copper Alloys. Guilliam H. Clamer, Philadelphia, Penn. (U. S. No. 1,198,618; Sept 19, 1916.)

COKE—Process of Making Coke. Henry W. Buhler and Charles J. Emerson, Boston, Mass., assignors of seven-eighths to George D. Haskell, Boston, Mass. (U. S. No. 1,191,943; July 25, 1916.)

CONCENTRATION of Ores. Raymond F. Bacon, Pittsburgh, Penn., assignor to Metals Recovery Co., New York, N. Y. (U. S. No. 1,197,590; Sept. 12, 1916.)

CONVEYOR MECHANISM. Hugh B. Lowden, Denver, Colo., assignor to Colorado Iron Works Co., Denver, Colo. (U. S. No. 1,199,580; Sept. 26, 1916.)

CRUSHER—Vertical Crushing Mill. Thomas Joseph Sturtevant, Wellesley, Mass., assignor to Sturtevant Mill Co. (U. S. No. 1,198,597); Sept. 19, 1916.)

CYANIDING—Process of Extracting Precious Metals from Their Ores. Albert E. Vandercook, Alameda, Calif., assignor of one-half to Leslie B. McMurtry, San Francisco, Calif. (U. S. No. 1,198,086; Sept. 12, 1916.)

DRILL—Pulsator for Pulsatory Tools. Lewis Condict Bayles, Eaton, Penn., assignor to Ingersoll-Rand Co., Jersey City, N. J. (U. S. No. 1,191,757; July 18, 1916.)

ELECTRIC FURNACE. Joseph Lawton Dixon, Detroit, Mich. (U. S. Nos. 1,197,458 and 1,197,459, Sept. 5, 1916; 1,198,625—Sept. 19, 1916.)

ELECTRICAL FURNACE. August Eimer, New York, N. Y. (U. S. No. 1,197,275; Sept. 5, 1916.)

EXCAVATOR. Walter Ferris, Milwaukee, Wis., assignor to Bucyrus Co., South Milwaukee, Wis. (U. S. No. 1,197,195; Sept. 5, 1916.)

FLOTATION—Apparatus for Separating Oiled Concentrates from the Gangue of Ores. Ralph T. Mishler, Pomona, Calif. (U. S. No. 1,197,843; Sept. 12, 1916.)

FLOTATION—Method of Treating Liquids with Gases. Charles S. Bradley, New York, N. Y. (U. S. No. 1,198,519; Sept. 19, 1916.)

FUEL—PULVERIZED-FUEL BURNER. Wirt S. Quigley, New York, N. Y., assignor to Quigley Furnace and Foundry Co. (U. S. No. 1,191,225; July 18, 1916.)

HOISTING MECHANISM. Harry E. Jenkins, Joplin, Mo., assignor of one-half to George H. Glade, Joplin, Mo. (U. S. No. 1,192,322; July 25, 1916.)

MELTING—Process for the Electric Melting of Metals. Charles Albert Keller, Paris, France. (U. S. No. 1,191,435; July 18, 1916.)

MOLD for Casting Steel Articles. Charles G. Robinson, Pittsburgh, Penn., assignor to Harry E. Sheldon, Pittsburgh, Penn. (U. S. No. 1,191,474; July 18, 1916.)

Editorial Correspondence

SAN FRANCISCO—Sept. 25

A Dividend from Cerro Gordo, California's premier silver-zinc mine, is just announced. The Cerro Gordo Mines Co., operating this old zinc-silver property in Inyo County, has declared a dividend of $25,000—2½c. per share. The mines were reopened three years ago under lease by L. D. Gordon, who a year ago became one of the principal owners and general manager. In the last year the mine has paid off an indebtedness of $40,000, expended $15,000 for improvements, paid $25,000 on outstanding shares and created a $50,000 treasury reserve, a total of $130,000. The company produces silver, copper, lead and gold, in addition to the zinc.

The Labor Strike in Amador County was precipitated without a demand being made upon the employers. The closing down of the mines without any effort to fill the places of the strikers was also an unusual proceeding. After denying that there was any intention of making a demand for increased wages, the union made a formal request for a meeting with the mine owners to discuss a uniform wage scale. This notice was delivered two weeks after the posting of the mine-owners' announcement that the mines would be closed if the demand for increased pay were made. The mine owners failing to reply to the note by Sept. 18, the union then ordered its members to remain away from work on the morning of Sept. 19 assigning as the reason that the mine owners had refused an increase in wages of 25c. per day per man. No demand had been made for the increased pay, but it is supposed that the union considered the announcement of Sept. 2 as being equivalent to a refusal. There are 1,500 mine employees in Amador County. About 1,200 were out on account of this strike. As evidence of the strength of the union and of the controlling element which brought about the strike, there was a mass meeting on Sept. 20 attended by about 500 men. This large attendance really surprised the strike leaders and encouraged them to have a parade next day. The parade formed at Jackson, marched to Sutter Creek, gathering up strikers at that point and then to Amador where others joined in the procession, making a total of about 255. The members of the local union number about 400 and it is believed that about 250 voted for the strike. A noticeable feature of the parade was the absence of Americans, Englishmen and Italians, and the preponderance of Austrians. Of the 11 mines, which signed the announcement of Sept. 2, three were exempted from the strike because they were paying a satisfactory wage scale. These were the Keystone, Original Amador and Consolidated Amador. The wage paid in these three mines was not a permanent and established scale, but a premium for rapid advancement of development and repair work. The strike leaders were anxious also to exempt the Plymouth Consolidated, because of the fear that if that mine, which is controlled by English investors, should close down, it might not be reopened again until the end of the European War. But the Plymouth closed on the day following the closing of other mines and on the next day the miners requested by petition that they be returned to work at the old scale and without recognition of the union, and the Plymouth resumed operation. The Original Amador, despite the fact that no strike was called in that mine, closed two days after the others had closed. The Keystone continued operation and the Consolidated Amador went ahead with its unwatering of the mine and repairing of the shaft. The mines which closed on the morning of Sept. 19 and remained closed are in the order of their situation, traveling north: The Argonaut, Kennedy, South Eureka, Central Eureka, Treasure, Bunker Hill, Fremont, a total of seven and with the Original Amador, of eight that remained closed during the week. It is evident that the strike was brought about by agitation from outside sources and that the majority of the union was in the early period of agitation, opposed to calling a strike, but the agitators worked chiefly among the Austrians and they are reported to have demanded that a strike be called. A peculiar feature of the whole affair is that at least 1,200 miners in the county were not in favor of the strike yet they allowed the remainder to close eight of 11 producing gold mines in the county, which has an annual production of about $2,000,000.

Later (by telegraph)—Many single miners leaving county. Companies giving men with families work on surface. No stamps dropping. Rumored that engineers will be asked by strikers to stop work.

BUTTE—Sept. 28

Anaconda in the Movies is the next step in its safety-first campaign. According to statement of H. J. Rahelly, of the U. S. Bureau of Mines, who is in Butte on an inspection trip, Anaconda is leading in the "safety-first" propaganda, having probably the largest mine-rescue crew in the world. From now on about 200 men will be prepared for safety work. Mr. Rahelly expects to pronounce 100 men qualified for this work this week. To bring the nature of the work to the knowledge of all employees and of the general public in Butte and to other districts of the country, moving pictures of operations at the Anaconda and Great Falls smelteries, and of demonstrations of first-aid and rescue work are now being made by the company and will be shown at theaters in Butte and in other towns where there are employees of the Anaconda company.

The Rich Strike in the Emma Mine of the Butte Copper and Zinc Co., which is being operated by the Anaconda company, attracted much attention in the district. On the 800 level, 15 ft. of high-grade zinc was cut and is said to be as rich as any zinc ore yet mined in the Butte district. Regular shipments are being made from the Emma to the concentrator at Anaconda but production is being held back by the delay in getting the refinery at Great Falls working to capacity. The Emma is capable of supplying from 800 to 1,000 tons of ore per day. The long crosscut that is being run from the Gagnon mine of the Anaconda company to develop the Emma at a depth of 1,600 ft., has reached a point about 200 ft. distant from the Emma shaft, where a raise will be made to connect with the shaft, now 800 ft. deep. Sinking will be started at the same time that work on the raise is begun.

A 2,000-ft. Development Tunnel is to be driven along the foothills on the east side by the North Butte Mining Co. to prospect its east-side properties. The preliminary work, upon which the engineers have been engaged for some months, was completed a few days ago and a small force of men at once put to work on the tunnel. Machinery is being installed to drive the tunnel about 400 ft. per month and it is expected that the entire work can be completed in five or six months. The portal of the tunnel will be on the south side of the Park Cañon entrance, just east of the Tropic mine of the Anaconda company, and will be driven south, back of the Bullwhacker property and the Montgomery claim of the Butte-Duluth company, the North Butte owning practically all of the mountain back of those properties. The tunnel will open the ground at an average depth of about 600 ft. and is expected to prove or disprove the many theories advanced by engineers and geologists regarding the possibilities of territory lying east of the continental fault, as an ore producer. The finding of ore-bodies in that district, which could be profitably mined and treated, would mean a great deal to Butte, as it would stimulate the exploitation of numerous other properties in that region which show surface indications as promising as those found on the North Butte holdings. Simultaneously with this new enterprise, the company is carrying on extensive development work in its older claims on Anaconda hill. Sinking at the Granite Mountain shaft has been carried to a depth of 3,710 ft., making the shaft the deepest in the camp. In view of the satisfactory showing on the 3,400 level of the Anaconda's High Ore mine, North Butte is planning to crosscut from the 3,710 station as soon as the latter is completed. On the 2,800 level the crosscut has encountered the Snowball vein now being developed by drifting.

DENVER—Sept. 28

Deep Mining in Cripple Creek District has proved a decided success. The latest big strike at depth being in the Portland mine, where on the 19th level (1,950 ft.) a stope of rich ore has been opened for more than 500 ft. The company's remodeled Independence mill is expected to be ready to begin operation about the first of January with a daily capacity of about 1,250 tons.

New Mining Companies Incorporated in Colorado, since the first of this year, number 350, according to Fred Carroll, commissioner of mines, who estimates that the 1916 output from the state's metal mines will exceed last year's total by 25%. The newly awakened interest in metal mining has been responsible for the revival of numerous old camps that have been practically dormant for a decade or more.

Portland's New Assay Office at Colorado City has been completed, replacing the one destroyed by fire some time ago. This office is said to be one of the most complete plants of its sort in the west. The company is progressing with the construction of its large sampling works at the Independence mine at Victor, although considerable delay has been experienced by labor difficulties in eastern factories that are furnishing equipment.

Vindicator's Flotation Mill which is being erected at Goldfield (Cripple Creek district) is nearly completed and operations will probably begin about the latter part of October with an initial daily capacity of from 350 to 500 tons. The mill occupies the site of the defunct LaBella Power Co.'s plant. Plans are made for gradually enlarging this plant to an ultimate capacity of 1,500 tons daily. The mine dumps of this company are estimated to contain 3,000,000 tons of rock carrying from $2 to $3 per ton in gold which it is proposed to put through this mill, mixing it with fresh low-grade ore from the mine.

MIDAS, NEV.—Sept. 27

Reduced Milling Charges by the Elko Prince mill has brought a more optimistic feeling in the Gold Circle district. Milling rates have been reduced $1 per ton for all grades, and a return of 92% instead of 85% is now made. Paul Ehlers is sending about 80 tons of ore to the mill from the June Bell lease and Noble & Stone have about 30 tons ready for a mill run. A matter of interest is the consolidation of the Missing Link and Rico groups into the Midas Merger Mines Co. Numerous shipments have been made both to the local mills and to the smeltery at Murray, Utah. Leasers have been operating in these properties for some time but it is expected that company work will soon be begun under the direction of Supt. M. J. Paisley.

MORENCI, ARIZ.—Sept. 28

Arizona Copper Co.'s Clay Mine Is Idle at present on account of a fire which started in a working stope Saturday night, Sept. 24, and which has not yet been extinguished. The origin of the fire is unknown, but it is thought it was caused by a burning candle left in contact with timber. The existence of the fire was not known until the shift went on Monday morning at 7:30 o'clock, as the mine was down Sunday and nobody passed through it. The stope is worked by a slicing system, therefore a great lot of old timbers is left in it, and by the time the fire was discovered, it had gained such headway that it was impossible to check it without bulkheading off all the rest of the mine. This is being done as fast as the helmet men both of the Arizona and the Detroit companies are able to do it, and it is thought that within 24 hr. more they will have the stope cut off entirely from the rest of the mine. Normal operations may then be resumed. D. A. Langley, a young mining engineer who was secretary to Peter B. Scotland, general superintendent for the Arizona company, lost his life on Monday in gas on the second level, which is two levels below the fire, it being on and above the adit. Mr. Langley was coming from Metcalf or Coronado on the second-level haulage road, which was not known to be gaseous at that time. The gas from the fire also penetrated the Copper Mountain and the Ryerson mines of the Detroit company in dangerous quantities in some places, but was soon bulkheaded off. The only production interrupted was that of the Clay mine itself and that of the Coronado mine, the latter's ore being ordinarily brought to Morenci via the second-level haulage road mentioned above.

HOUGHTON, MICH.—Sept. 29

Developments in the Osceola Lode in the most southerly extensions of the drifts from the Osceola mine have recently engaged local attention. These extensions run into the La Salle property and the grade of the rock opened is the best ever found in this branch of the Osceola lode. The operations on the La Salle property have been continued, in a limited way, all this year, as they were last year. They were profitable, notwithstanding the comparatively small amount of copper taken out and the low percentage obtained per ton of rock. The rock was stamped at the Franklin mill. But the openings on the La Salle property, have never been looked upon as promising for the future of the mine. The showing of nine pounds per ton is too small to operate profitably excepting under abnormal conditions. However, all of the work done on the La Salle, since the Calumet & Hecla took over the Tecumseh and other property which became part of the La Salle, has been confined to the Kearsarge amygdaloid, which apparently dwindled considerably in content at this point. Last year the old Osceola extended southerly drifts from No. 6 shafts to the La Salle boundary and mined its best rock there. Last week another extension to the boundary was made and the showing was even better. Of course, for the La Salle to operate in this territory means either a working contract with Osceola and a long lateral haulage and nearly a mile hoist afterward or development by new shafts from the La Salle surface, so that no immediate advantage to La Salle is in sight. But the Osceola developments, in this old Osceola lode, are of particular advantage as showing a possible future for La Salle on a lode hitherto considered of questionable merit.

Versatility of the Copper Miner in the Lake Superior district was illustrated when the strike of the railway employees seemed probable. Most of the mines here are served by local railways, and the men are not as a rule members of the Brotherhood. Calumet & Hecla, Isle Royale and Quincy have their own railways, operated by their own nonunionized men—or if they are organized their runs are so short that they would not be called in a strike. But the mines served by the Mineral Range Ry., a subsidiary of the Duluth, South Shore & Atlantic Ry., were ready to go on strike. The injustice of a force of 130 men, constituting the train crews on these ore-hauling lines, forcing 8,000 or more mine employees into idleness for their demand for an increase in pay, when they already receive higher pay than the average mine employee, did not appeal to the miners. To be fair with railway men so involved, none of them wanted to strike, few of them attempted to justify the strike and did not intend to strike except as a matter of sticking to the fellow railway unionists. But unless the "rock" from the mines is hauled away with facility it is quite impossible to operate any copper mine to capacity. Some of the men might be utilized to help in advancing underground openings and some might be placed in other mines not damaged by the strike. When it looked as if the strike would come and orders to strike actually were received the officials of the Mineral Range were astonished to find applications for railway jobs from 100 former railway men who wanted jobs back again and these applications came without solicitation. A hurried canvass of one mine showed 200 men with railway experience and every man was willing to go to work to help keep the 8,000 other mine employees on their jobs.

JOPLIN—Sept. 30

Inefficient Use of Powder in this district was charged by a representative of the du Pont company in an address before a meeting of mine operators during the last week. Operators were informed if they would use lower grade powders with higher grade detonators, they would get as good results as they were obtaining with high-grade powders with low-grade detonators, and powder bills would be considerably decreased. He also advised that all holes be tamped.

Settling of Slimes in Joplin mills has been the subject of considerable study by the Dorr representative in this district, Charles W. Burgess, and further improvements in this department are expected. Mr. Burgess recently sent to the company's laboratories at Denver a representative assortment of slimes from local mills. He left Sept. 29 to conduct experiments to determine settling rates of the different slimes. During the last year about 40 thickeners have been installed in this district.

TORONTO—Sept. 30

Gold Discovery is reported near Bourke's station at mileage No. 184 on the Temiskaming & Northern Ontario Ry. A settler named Anderson in clearing his farm uncovered a wide vein, with visible gold, extending across his property. A rush of prospectors to the district has begun.

Metal Production in Ontario for the first half of 1916 was much larger than in the corresponding period of last year, according to returns to the Ontario Bureau of Mines by the metalliferous mining companies of the province. The output reported was gold, 235,060 oz; silver, 10,267,743 oz.; copper, metallic, 77,795 lb.; copper in matte, 11,426.5 tons; nickel in matte, 20,651.5 tons; nickel, metallic, 13,933 lb.; cobalt, metallic, 121,817 lb.; cobalt and nickel oxides, 401,408 lb.; molybdenite, concentrates, 12,631 lb.; iron ore, 80,698 tons; pig iron, 295,349 tons. If the present rate of production is maintained the gold output for the year will reach approximately $10,000,000 as compared with $8,500,000 for the previous year. The Hollinger and the Dome are the two big producers, although the McIntyre is rapidly increasing its production. The number of ounces of silver is less than for the corresponding period of 1915 but on account of the higher price the value of the output shows an increase of $1,000,000. Practically all the silver comes from Cobalt and the life of the camp will be prolonged by the introduction of the flotation system for the treatment of low-grade ores and old tailings. The most important increase was in nickel with a value of $10,325,766 as compared with $7,591,000 for the corresponding period of 1915, and $2,872,843 in 1914. The value of the cobalt and nickel oxides has increased about 400 per cent. due to the opening up of new markets on account of war conditions. The total value of the production for the six months is $28,631,292 as compared with $21,255,583 for 1915, or a gain of 34.7%. It is expected that this increase will be maintained if not exceeded for the rest of the year.

The Mining News

ARIZONA

Cochise County

BUNKER HILL MINES (Tombstone)—Has added eight stamps to mill.

COPPER QUEEN (Bisbee)—At the testing plant at Lowell experiments have been started on the sulphidizing and subsequent flotation of carbonate tailings from Morenci.

BISBEE COPPER MINING AND DEVELOPMENT (Bisbee)—New copper flotation to develop 237 acres north of the Copper Queen holdings. Two churn drill holes have been sunk to 185 and 267 ft. respectively, and hoisting equipment capable of sinking 1,000 ft. is to be used on proposed 3-compartment shaft on Pauline claim. A. H. Livingston, secretary.

KEYSTONE COPPER (Johnson)—Two-compartment shaft has reached 500-ft. mark; in low-grade ore for over 200 ft.; last 15 ft. ran 3% copper. Company owns 310 acres about 2 mi. from Johnson. Its O. K. shaft is down about 70 ft. and in high-grade sulphide ore. Equipment consists of 30-hp. gasoline hoist, 28-hp. crude-oil engine running four-drill Ingersoll-Rand compressor and jackhamers, used in shaft—sinking about 2½ ft. per shift. U. R. Miller in charge.

Gila County

NEW DOMINION COPPER (Globe)—New organization of Pennsylvania oil men has taken over Mallory property.

Mohave County

NELLIE (Oatman)—Has cut station at 350-ft. level.

OATMAN CRESCENT (Oatman)—Again driving adit to tap vein at 300-ft. level; in about 450 ft.

BIG JIM (Oatman)—Raising from 400-ft. level to ascertain upward extension of big oreshoot.

Pima County

NEW CORNELIA COPPER (Cornelia)—Preliminary leaching operations begun though entire plant not yet ready.

CORNELIA EXTENSION (Ajo)—Hoisting high-grade material from new shaft at 65-ft. depth; 3 drill holes down to depth.

Yavapai County

SILVER BELL (Humboldt)—Plan to sink new 1,000-ft. shaft; electrical machinery to be added.

ARIZONA & ARKANSAS (Jerome)—Unwatered and will resume operations as soon as machinery arrives.

COMMERCIAL COPPER (Copper Basin)—Will resume shipments to United Verde smeltery at Clarkdale.

VENTURE HILL (Jerome)—A 3-ft. vein malachite, containing also native copper, struck in tunnel 275 ft.

JEROME VICTOR (Jerome)—The 1,200-ft. shaft and all workings unwatered. Will extend west crosscut on bottom level.

OCTAVE (Wickenburg)—Will now resume operations after expert examination; 27-in. vein said to average $10 a ton for 270 ft.

UNITED VERDE EXTENSION (Jerome)—Winze being sunk from 1,400 to 1,600-ft. levels opened big flow water at 115-ft. point.

BIG LEDGE DEVELOPMENT (Huron)—No. 2 shaft sunk 147 ft. farther to level of lower tunnel; sinking new Le Duc shaft, 800 ft. south.

ARIZONA SAMPLING AND REDUCTION (Wickenburg)—New company will build custom sampling mill, and a concentrator of 50 tons daily capacity.

CONSOLIDATED ARIZONA SMELTING (Humboldt)—Considering addition new furnaces; concentrating and sampling plant destroyed by fire now rebuilt.

JEROME VERDE (Jerome)—Sandstone formation reached in enlarging 700-ft. shaft from one to three compartments; new electric pumps easily handling all water.

GREAT WESTERN SMELTERS CORPORATION (Mayer)—Issuing $250,000 in bonds to remodel old Treadwell smeltery and may add another furnace. Will smelt ores from Big Ledge Development Co., with which smelting company is allied.

GLADSTONE-McCABE (McCabe)—These mines to be reopened at once by C. M. Garrison and associates, of New York. Ore can be shipped within six weeks, as all mining machinery is in place.

DUNDEE-ARIZONA (Jerome)—Work suspended pending arrival adequate pumps to handle water struck 450-ft. point; during shutdown 60-hp. engine will replace present one of 25 hp. and larger compressor will be installed.

GREEN MONSTER (Jerome)—Plans to sink two 150-ft. shafts on Amazon & Missouri claims; the George tunnel on the Cliff claim has been cleaned out and track laid to the elbow about 800 ft.; two crosscuts being made from Revenue tunnel; 6,000-ft. pipe line laid to Cliff Creek.

VERDE COMBINATION COPPER (Jerome)—At recent meeting of stockholders, John L. Dyer, of El Paso, was elected president; Alfred F. Kerr, of El Paso, vice-president; above officials and R. M. Dudley, W. N. Richards, John S. Eberman, J. C. Callaghan and James M. Layman comprise the directorate.

Yuma County

UNITED MINES (Plomosa)—Bought 13 claims from J. C. Denton for $18,000.

CALIFORNIA

Amador County

EIGHT PRODUCING GOLD MINES of Amador County were closed during the week of Sept. 22 on account of alleged refusal of mine owners to discuss wage scale with United Federation of Labor. The union numbers about 400 men, about half of whom were opposed to the strike. The mines remaining closed down during the week are the Argonaut, Kennedy, South Eureka, Central Eureka, Original Amador, Treasure, Bunker Hill and Fremont. The Plymouth Consolidated was closed for a few shifts, but resumed operation on petition of the miners. The Keystone did not close because a premium of 25c. per day was being paid for rapid development. Consolidated Amador continued unwatering and repairing shaft and for that work was paying an extra 25c. per day.

PLYMOUTH CONSOLIDATED (Plymouth)—Newly installed Nordberg electric hoist has capacity 5,000 ft. depth; double-drum gear, drums 9 ft. diameter, 88-in. face, each grooved for 5,000 ft. of 1⅜-in. rope; hoist provided with Welch safety stops; shipping weight, exclusive of electrical apparatus, 220,000 lb. First 1,520 ft. of shaft is vertical, then inclined at 60°.

BUNKER HILL (Amador City)—Shaft lined with concrete to depth of 225 ft. This improvement practically completed when general strike was called; one man, retained on finishing work on the second day of the strike, was badly beaten by strikers as he came off shift at 11 p.m. This shaft collar caved about four years ago locking some of miners in lower workings for about a day.

Calaveras County

PIONEER (Angels Camp)—Crosscutting and drifting discontinued and sinking now in progress; shaft will be deepened to 500 ft.

MOUNTAIN KING (Hodson)—T. Silva killed at 600-ft. level by explosion of a missed hole on Sept. 19; another man severely injured.

Colusa County

BOGGES QUICKSILVER (Williams)—New oil-burning furnace being installed; stated that saving of $100 per month will result from substitution of oil for wood. Monthly output reported at 80 flasks.

Eldorado County

CHROME DEPOSITS on the Pilliken place on Negro Hill, owned by Hill & Hobler, reported sold to Noble Electric Steel Co., operating smeltery at Heroult, Shasta County. Ore will be hauled on motor truck to Folsom for shipment by rail.

Glenn County

CHROME DEPOSITS near Fruto said to have been worked out, so far as high-grade ore is concerned, and property closed pending prospecting for new deposit or continuance of old one.

Inyo County

SANTA ROSA (Keeler)—Hauling ore from mine to railroad with caterpillar tractor and five trailers, capacity 25 tons per trip; 1,500 sacks ahead of teams necessitated adoption of caterpillar. Company employing 10 men; 23 working on 15 leases; most leasers working from surface by underhand stoping; ore high-grade.

Kern County

SERIES OF FIRES at Randsburg Sept. 17; incendiarism suspected. Reward of about $300 offered for conviction of incendiaries. Buildings destroyed or damaged were owned by Judge E. D. Maginnis, Dr. O. L. Cochrane, O. F. Ranaldi, David Thompson and Mr. Hartley.

Nevada County

DELHI (Nevada City)—Unwatering shaft; water lowered to 300-ft. point, making 50 ft. per week; shaft 500 ft. deep. Property in Columbia Hill district, formerly owned by St. Gothard Mining Co., now being financed by Nevada City men.

Placer County

DREDGE PROSPECTING by the Guggenheims reported on north fork of American River near Codfish Cañon; ground said to be the Bond claim and ¾ mi. of river bed owned by Boswell Dunlap; lower parts of river gave rich gold returns in early days.

San Bernardino County

ATOLIA (Atolia)—Has 30 men at work in Churchill shaft; operation of mill not resumed.

Siskiyou County

McKEEN (Callahan)—New mill and other machinery will be installed at this old producer, now operated by San Francisco men; W. L. Fraser in charge.

Tuolumne County

SPRINGFIELD TUNNEL (Columbia)—Rich gravel reported in ground purchased from Ranch Mining Co.

SWADLY (Soulsbyville)—Bonded to San Francisco men who have installed hoist and compressor and begun development.

NEW YORK (Sonora)—The 90-ft. tunnel has been extended into the river side of the hill to a point 250 ft. below earlier exploration. Property in East belt of the Mother Lode.

COLORADO

Boulder County

BOULDER TUNGSTEN PRODUCERS' special committee met in Boulder Sept. 13 to draw up brief stating reasons why tungsten industry should have protective tariff. Further steps will be taken later.

UP TO DATE (Boulder)—Recent development opened rich silver-gold-copper ore.

FAIRFAX (Salina)—Fortune vein cut and streak of sylvanite ore opened. Work in progress on all four levels.

HERALD (Boulder)—Leased from John Yates by Heane & Withrow. Larger hoist will be installed and shaft sunk additional 100 ft.

BISMARCK (Caribou) — Bonded by Fred Carlson and August Wilimzik. Opened 8-in. streak of 40-oz. silver ore. Main tunnel advanced 300 ft.

AMERICAN (Boulder)—Mine will be reopened and flotation plant installed. Property once producer of high-grade gold-telluride ore. Ore of milling grade left in mine.

UNITED STATES GOLD CORPORATION (Boulder)—New pumping plant being installed. Winze below fourth level will be unwatered and sinking resumed. High-grade ore opened in this winze but was followed by cutting of water course which forced temporary suspension. Same oreshoot opened on 500-ft. level by recent development.

Clear Creek County

PITTSBURGH (Breckenridge)—Shaft unwatered and retimbered. Crosscutting under way.

BULWER-STANDARD (Breckenridge)—Good-grade gold-silver-lead ore being mined. Shaft 50 ft. deep.

COHOMACK (Breckenridge)—Mill running on ore from the Puzzle dump. Two cars concentrates shipped recently. Puzzle mine also shipped car smelting ore.

CAPITAL (Georgetown)—Recent strike of gold-bearing quartz richer than first anticipated. Two feet of quartz on hanging-wall of vein stoped shows free gold in wires and flakes. Strike made in Hanson and Walthers lease at raise No. 15 west.

LAMARTINE (Freeland)—Taken over by Broderick Mining Co. Extensive development planned under management of I. W. Clokey. A 150-ton mill may be built near portal of old Lamartine tunnel. Flotation will be used. Old dump estimated at 50,000 tons will be treated.

Lake County

GOLD STRIKE ON RED MOUNTAIN in Twin Lakes region made recently by Mock and Hartman. Buildings being constructed and work will be continued all winter. Reported a second strike made on Bowerman group in same district.

HIBSCHLE (Leadville)—Surface plant formerly at Walcott shaft moved to this property. Walcott, Coronado and Hibschle under lease to Otto Thum and others. Heavy flow of water in Walcott workings prevented working through that shaft.

San Juan County

MEARS-WILFLEY MILL (Silverton)—Plant completely overhauled; is now operating on three shifts.

HIGHLAND MARY (Silverton)—Developing on two shifts. Ore shipped to North Star mill. J. H. Slattery, manager.

REWVILLE (Ironton)—This Red Mountain property is being developed by Hoffman and Flinn. New mine boarding house completed.

SILVER LEDGE (Chattanooga)—Being developed under management of Philip Sartore. Mill running on day shift making lead and zinc concentrates, shipped to Durango smeltery.

KITTIMAC (Silverton) — Crushing plant at mine being overhauled and cribbing constructed to protect tramway against snowslides during coming winter. Mill will be in operation soon with new flotation equipment.

ELK MINING AND MILLING (Silverton)—Contract to advance tunnel 500 ft. nearly completed. Company contemplating installation of compressor and machine drills to expedite development; property in Cement district; J. J. Cusick in charge.

San Miguel County

MATTERHORN MINING AND MILLING (Butterfly)—The 4,000-ft. crosscut being retimbered preparatory to advancing 600 ft.

CLIFF DWELLER (Norwood)—Leased by G. G. Galloway to Gibbs and associates who are developing a 12-in. vein of shipping ore.

SILVER BELL (Ophir Loop)—Two-compartment raise from tunnel level has broken through into sixth level, having been extended 828 ft. on the vein. Underground exploration will continue under F. E. Trumble.

IDAHO

Blaine County

MASCOT (Hailey)—Ore opened beyond faulted zone formerly worked and flotation plant may be erected.

Elmore County

RICH GOLD ORE reported opened at depth in one of the old mines at Atlanta, 80 mi. from Boise.

Shoshone County

COPPER KING (Mullan)—Diamond drill in 480 ft. from west drift of lower tunnel cut lead-copper vein. Crosscut will be run to orebody about 400 ft. from drill hole and will then drift toward latter. D. K. McDonald and other Spokane men interested; H. W. Ingalls, secretary.

SUNSHINE (Missoula, Mont.)—Ingersoll-Rand compressor and drills being installed to continue crosscut adit to get 450 ft. additional depth on the Toughnut orebody. Consolidation with other Beaver Creek properties under consideration but will not include Ray-Jefferson, as reported. Dr. E. G. Ellis, treasurer.

MICHIGAN

Iron

SUNDAY LAKE (Wakefield)—A Greene economizer and automatic stokers are being installed. A 30-ft. addition has been made to the boiler house. About 40,000 tons of ore averaging from 37 to 40% shipped from stock piles. Ores of higher grades also moved.

WAKEFIELD (Wakefield)—New pit "C" to be opened short distance from main pit. Overburden will be moved by hydraulic method. Is 65 ft. deep; about 600,000 cu.yd. will be moved. Some ore will be taken up inclines on side of pit; remainder will be milled. Owned by M. A. Hanna Co.

EUREKA (Ramsey)—Sixteen new company houses are to be built this winter. Concrete foundations now being put in. A new first-motion steam hoist to be purchased for No. 2 shaft, not in use now. New orebody found in the western portion of mine—not a continuation of Anvil orebody. Drill hole will be put down 1,100 ft. from surface to prospect for Anvil extension.

MINNESOTA

Cuyuna Range

TOD-STAMBAUGH CO. (Riverton)—Optioned lands adjacent to Rowe mine, with intention of stripping the property. Company also has option on lands in the manganiferous belt, held by Gopher Iron Co.

THOMPSON (Crosby)—First Cuyuna Range ore from a state-owned property shipped Sept. 26, when 50 tons were loaded from a state forty, leased to Inland Steel Co. The forty will be stripped and become a part of the Thompson pit.

Mesabi Range

HARTLEY (Chisholm)—Stripping started. One shovel and two locomotives working. No shipments will be made until spring.

HOLLAND (Biwabik)—The 30,000-ton stockpile purchased by John A. Savage, of Duluth, and is being shipped. Mine idle for several years.

BESSEMER (Franklin)—Three shafts are to be opened. J. S. Lutes, of Duluth, has control. Was operated from 1902 until recently by Republic.

DONNER MINING CO. (Hibbing)—Mining department of Donner Steel Co. has lease from Alexandria Iron Co. on four 40-acre tracts west of Hibbing, known as the St. Anthony No. 1 and No. 2 mines.

CHISHOLM (Chisholm)—Production will be started shortly. Ore will be trammed to "B" shaft of the Monroe property. Hoist now being installed at Monroe. Concreting being carried on in Chisholm shaft. Will not be in commission until first of year.

MISSOURI

Joplin District

WHITE OAK (Cave Springs)—Planning custom mill.

ST. REGIS (Joplin)—Opened rich disseminated formation at new property at Chitwood. New mill started.

MONTREAL (Century, Okla.)—Framework of new mill up; machinery to be installed soon. Sinking shaft.

A. R. G. (Duenweg)—New 400-ton concentrating plant started. All machinery on concrete foundations. Separate steam engine operates slime department and electric-light plant. Mining at 200 ft.; only one shaft now complete, but second to be ready soon. Concentrates run about 63% zinc.

Northern Arkansas

EUREKA HOLLOW (Tomahawk)—New mill contract let to Joplin contractor.

WHITE EAGLE (Rush)—Compressor installed; track from tunnel to mill completed and mill in operation.

BONANZA (Buffalo)—Sold 100 tons of its reserve concentrates to Fort Smith Spelter Co. which so far has not been able to get the 500 tons per month desired from this district.

MONTANA

Lewis and Clark County

THOMAS CRUSE MINING AND DEVELOPMENT CO. (Helena)—Executors of Thomas Cruse estate have transferred Franklin mine in Scratch Gravel district, near Helena, to this new company. Richard Cruse, president.

Silver Bow County

DAVIS-DALY (Butte)—Colorado orebody opened for 450 ft. on 2,500 level where Hesperus vein has been identified. Average width 12 ft., carrying 5 to 7% copper.

BULLWHACKER (Butte)—At depth of 110 ft. a crosscut, run 60 ft. from glory hole, opened body of rich copper ore. Leasing company. Management planning to sink shaft to 200 level and crosscut for orebody just opened.

LA FRANCE (Butte)—Atlantic Mines Co. which took over this silver-zinc property three years ago did not succeed in its exploitation and will sell the property at public auction Nov. 1. Anaconda is stated to have offered $10 per share and interest, plus the $250,000 which Atlantic spent in the exploitation.

NEVADA

Esmeralda County

CHAMPS D'OR GOLD (Hornsilver)—Dunfee lease resumed. Some ore will be shipped but plan is to block out sufficient ore to warrant mill.

JUMBO EXTENSION (Goldfield)—Optioned Kanrohat mine in Jefferson Cañon, about 6 mi. from Round Mountain, Nye Co. Contracts let for preliminary development.

GOLDFIELD CONSOLIDATED (Goldfield)—Final August figures were: Net realization, $18,211 from 17,300 tons; net costs, $7.43 per ton, including 64c. for construction.

PALMETTO CONSOLIDATED (Goldfield)—For six months 10 men have been developing claims of old Palmetto Mining Co. on south slope Palmetto Mountain about 35 mi. southwest. Some ore being stoped.

Lincoln County

GROOM (Pioche)—Regular shipments continue via Indian Springs station, 60 mi. from mine. Road being improved and expect to haul 30 tons per trip with "Cat" and six trailers. Ore carries about 60% lead and 20 oz. silver.

Lyon County

MASON VALLEY MINES (Mason)—New offering of 200,000 shares to stockholders at $5. Has acquired Gray Eagle group of 14 claims at Happy Camp in Siskiyou County, Calif., developed by John B. Farish and F. H. Dakin.

Nye County

TONOPAH ORE PRODUCTION for week ended Sept. 23 was 9,568 tons valued at $198,104 compared with 9,247 tons for week previous. Producers were: Tonopah Belmont, 3,094 tons; Tonopah Extension, 2,200; Tonopah Mining, 1,950; Jim Butler, 1,000; West End, 831; Rescue-Eula, 213; Halifax, 162; North Star, 54; miscellaneous 64 tons.

Storey County

ANDES (Virginia)—Saved 40 cars from development on 350 level.

MEXICAN (Virginia)—Old west crosscut 2,500 level reopened and repaired 60 ft. to 170-ft. point. Mill crushed 446 tons custom ore, average $15.26.

SIERRA NEVADA (Virginia)—Raise in northwest drift, 2,400 level, advanced 12 ft.; saved 32 tons, average $21. Saved 41 tons from south boundary stope, average, $8.98. North drift 2,500 level repaired 20 ft. to the 280-ft. point.

UNION CON. (Virginia)—Shipped 446 tons to Mexican mill, gross value about $6,700. Extracted 373 tons from 2,400 and 2,500 stopes and development work; 30 tons averaging $14.40; 41 tons, $14.58; 65 tons, $10.72; 27 tons, $9.78; 84 tons, $13.60; 126 tons, $17.76. West crosscut from 2,600 station, joint Union-Sierra Nevada winze, advanced 16 ft. Continued repairs in the 2,700 winze.

TENNESSEE

TENNESSEE ZINC CO. (New Tazewell)—Has repaired mill and is again operating its mine on Straight Creek, Claiborne County. L. L. Bristow, manager.

TENNESSEE COPPER (Copperhill)—Readjustment of company's affairs proposed on basis of doubling capital stock, new shares to be offered to shareholders at $16. Adolph Lewisohn may become president.

TEXAS

CHISOS MINING (Big Bend)—Recently shipped carload quicksilver valued at $25,000.

UTAH

Box Elder County

LAKEVIEW MINING (Saline)—Shipped six cars of zinc and lead ores in August. Leasing system adopted, 10 sets of lessees, employing 20 men. Zinc ore shipments run about 32%; lead ore ranges from 18 to 28%. Dividends to date $124,000. S. S. Arentz, manager.

Juab County

TINTIC SHIPMENTS for week ended Sept. 22 amounted to 183 cars.

TINTIC STANDARD (Eureka)—Shipping ore opened on lower level. Company owns 1,800 acres, 200 of which are patented.

COLORADO CONSOLIDATED (Silver City)—Drifting for 400 or 500 ft.—under contract to Walter Fitch, Jr.—will be done on 1,500 level.

SIOUX (Eureka)—Contract for sinking shaft to 1,000 level let to Duncan & Allen. Work through winze being done at depth of 675 ft.; formation similar to Iron Blossom at same depth; searching for continuation of Iron Blossom copper deposit opened at 800 ft.

Salt Lake County

BAKER MINING (Salt Lake)—Four inches of silver-lead ore showing in bedding, on tunnel level.

SOUTH HECLA EXTENSION (Alta)—Two cars of good ore shipped. Main workings reported to have flow of 3,000 gal. water per minute.

OHIO COPPER (Bingham)—Stay to confirmation of foreclosure sale gives stockholders until Oct. 13 to demonstrate ability to redeem property.

EMMA COPPER (Alta)—Diamond drilling in old Emma ground is affording interesting results; the second hole reported to have cut ore, having been driven through 15 ft. of shipping grade.

Summit County

PARK CITY SHIPMENTS for week ended Sept. 22 amounted to 2,962,379 lb.; shippers were Silver King Coalition, Daly West, Ontario, Silver King Consolidated, Judge Mining, Daly and Naildriver.

DALY (Park City)—Prospecting for continuation of ore-bearing veins of district. Some comparatively small bodies of ore of good grade opened, and knowledge gained in regard to faults and displacements affecting Ontario vein. Ore of good grade also found in limestone bordering on Daly vein. Considering 150-ton mill to treat by concentration and cyanidation ore left in stopes, and low-grade lead- and zinc-sulphide ore on lower levels. Shipments week ended Sept. 22, 65,260 lb.

Utah County

EUDORA BELL (American Fork)—Compressor repaired, and miners put on by Red Cloud Mining Co. operating this property.

MAJOR EVANS (American Fork)—Bunk houses and other improvements completed, and development will continue through winter. Will sink shaft. Eight men employed.

PACIFIC (American Fork)—Another car high-grade silver-copper ore shipped. One is at the smeltery, and two more are on the road. New mill expected to be ready in about a month.

WYOMING

PENN-WYOMING BONDS were sold at auction in Cheyenne to Raymond W. Starr, of Grand Rapids, Mich., for $83,000 to satisfy judgment obtained by Vivian E. Collins and the Continental & Commercial Trust and Savings Bank, of Chicago. Purchasers it is said may reorganize properties.

CANADA

British Columbia

PARADISE (Windermere)—Resumed ore shipments after idleness of 10 years. Eight teams hauling silver-lead ore to railway and 21 men are employed at mine. Short aërial tram being constructed to storage bins on line of the Kootenay Central Ry.

GALENA MINING AND MILLING CO. (Spokane, Wash.)—Organized to acquire the Galena Farm with its mill, near Silverton. Was bonded to late Patrick Clark a few months prior to his death. Since then about $150,000 has been expended in development, and equipment of mill and power plant. Net returns of $20,000 to $25,000 monthly.

COAST COPPER CO., LTD. (Trail, B. C.)—This new company formed to develop 31 copper claims on north end of Vancouver Island, acquired from W. E. Cullen and Maurice F. Bacon, of Spokane. Properties near Elk Lake which drains into southeast arm of Quatsino Sound. Low-grade deposit; some diamond drilling done. Consolidated Mining and Smelting Co. reported interested.

ONTARIO

AUGUST SHIPMENTS of silver ore from Cobalt over Temiskaming & Northern Ontario Ry. are reported by Arthur A. Cole as follows: Alladin, 25.20 tons; Beaver, 52.61; Cobalt Comet, 52.47; Coniagas, 71.23; Crown Reserve, 77.66; Kerr Lake, 110; La Rose, 130.88; McKinley-Darragh, 214.68; Mining Corporation of Canada, 183.20; Nipissing, 539.66; Penn Canadian, 43.74; Right-of-Way, 43.71; Trethewey, 38.28; total Cobalt proper, 1,583.32 tons; Casey Cobalt (New Liskeard), 30.46 tons; Miller Lake O'Brien (Elk Lake), 28.80; total silver ore shipments, 1,642.58 tons. Nickel ore, Alexo mine (Porquois Junction), 672.15 tons.

DAVIDSON (Porcupine)—Main vein 35 ft. wide on 100-ft. level. Station cut at 300-ft. level and cross-cutting started.

INSPIRATION GOLD (Porcupine)—New company to operate Shillington Richardson property near the Hollinger.

TASH-ORN (Tashota)—Compressor and other machinery being installed on Wells' claim; vein, 20 ft. wide, found adjacent to King Dodds claim, Kowkash.

MAIDENS MACDONALD (Porcupine)—New compressor will be installed; under option to the La Rose. Two shafts 600 ft. apart will be connected on 100-ft. level.

NIPISSING (Cobalt)—Paying 5% bonus in addition to regular quarterly dividend of 5%. Cash on hand Sept. 26 $1,218,838, and ore and bullion $957,314; total $2,176,163.

KERR LAKE (Cobalt)—Report for year ended Aug. 31 expected to show production of 2,300,000 oz.; cash and ore on hand about $1,000,000. Ore reserves practically the same as for previous year.

SENECA-SUPERIOR (Cobalt)—Declared dividend of 20c. a share; government tax was $15,000. Payment of this dividend will leave only small amount in treasury. Mine has been closed and plant sold.

INTERNATIONAL NICKEL (43 Exchange Place, New York)—Has taken option on group of seven nickel claims owned by Reamsbottom and Edwards in Langmuir township, near Frederickhouse Lake. Diamond drill will be sent in.

DOME (South Porcupine)—New working shaft is expected to be completed in October. During winter months less ore will be drawn from open cuts and, as the deficit will be made up from ore from lower levels, a higher grade is expected.

DOME EXTENSION (South Porcupine)—The deep diamond-drill hole was stopped at 2,000 ft. without cutting the Dome orebodies; hole changed its course and capacity of drill was reached before passing through the porphyry. Some good ore was cut in the center of the porphyry, where it was not expected. It is improbable that another deep hole will be drilled as developments in other sections have been favorable and there seems no doubt of the option being exercised by Dome Mines, Ltd.

NEWFOUNDLAND

NOVA SCOTIA IRON AND STEEL (West Wabana)—At iron mines on Bell Island, underground operations in the submarine areas are more active than for some time. The sinking of new slopes and crosscuts has been hastened. Recently a bad blasting accident occurred, several men being killed. Some interesting grouting of water seams in the back has been done by a machine on wheels that forces cement into the crevices (cement gun ?). While the summer's shipments were not up to other seasons, account stoppage of shipments to the Krupps in Germany and high ocean freights to England and America, preparations are being made for heavy shipments when more vessels are available. Ore is about 50% iron and high in phosphorus, being blocky and hard. Bethlehem Steel Co. has been a user but main consumption has been in company's own furnaces at Sydney and in the Dominion Iron and Steel Co.'s furnaces at same place. Shipping season will soon be closed by ice packs in Conception Bay.

CUBA

REPORTED POTASH DISCOVERY not yet authenticated. American consul general at Habana cabled Sept. 26: "Best information obtainable here indicates report as to potash deposit discovered not well founded. Will investigate further."

MEXICO

CIA. DE REAL DEL MONTE Y PACHUCA (Pachuca, Hidalgo)—American staff withdrawn in June now returning. Loreto mill on the Pachuca side is operating and the Guerrero mill is expected to start early in October. Officially stated that arrangements have been made that should solve difficulties due to cyanide shortage. Rumored that new method (flotation ?) will be adopted.

The Market Report

Metal Markets

NEW YORK—Oct. 4

Copper was strong at unchanged prices, except that an advance had to be paid for prompt delivery. A moderate volume of business was done. Lead was quiet and strong. October delivery, not previously contracted for, is scarce. Spelter showed a rising tendency on relatively light transactions.

Copper, Tin, Lead and Zinc

Copper—A fair volume of business was done at about the same prices as in the previous week. Small sales of prompt copper were made at 29c., r.t. A considerable amount of December copper was sold at 27¾@28c., net cash, New York, but it was only from one or two quarters that December delivery was available, producers in the main being fully sold out for the remainder of this year. The major market during the last week was for delivery during the first quarter of 1917, all of which business was done at 27c., r.t., equivalent to 26¾c., net cash, New York, while some business for January alone was booked at the same price. Several producers sold for delivery in the second quarter of 1917, acepting 26c., r.t., equivalent to 25¾c., cash, New York, a fairly large tonnage being booked for that delivery at that price. There were a few sales for export, but the major part of the business of the week was for delivery to domestic manufacturers. The aggregate of sales whereof we had reports was about 20,000,000 lb., compared with about 18,000,000 lb. in the previous week, the average realized on all business being about the same.

Many important domestic manufacturers have not yet booked the copper that they are normally expected to require in the first quarter of 1917, and it is the general belief among producers that the copper market has not yet responded to the change in statistical position produced by the recent large sale to the foreign governments. A noteworthy feature of last week was some important buying by wire manufacturers. A correspondent communicates the following interesting news respecting the situation among the brass makers of the Naugatuck Valley:

Copper Sheets continue unchanged at 37.5 for hot rolled and 38.5 for cold rolled. Wire has advanced slightly, quotations now being 32@33c.

Brass manufacturers are extremely busy and well booked ahead. The dearth of crucibles and the labor shortage during the summer reduced output about 33⅓%, and the pressure of these accumulated demands is forcing consumption to the very limit of capacity. What with the lack of reserves of electrolytic, this may cause an acute shortage for early delivery, and belated buyers will pay through the nose. Of course, the important ones are well covered; it will be the stray dog that will be hit. For next year's delivery, buyers are covering only as they sell manufactured material, and there is considerable if not most of the copper required still to be bought for first quarter.

Tin—A better business was done, chiefly for foreign delivery. On Oct. 3 a large business was done.

Lead—A good business was done, but the aggregate, as reported by producers, was a trifle less than in the previous week. Prices were unchanged, and on the whole were maintained stiffly, but there was some competition among producers for orders at interior points which resulted in trifling concessions in order to get the business. A little export business was done. Lead for October delivery, not previously contracted for, continues extremely scarce.

Spelter—This market improved from day to day on relatively light transactions. There was a good demand for October spelter, and producers appeared unwilling to sell it except on better terms. On the other hand, everybody was eager to place business for delivery in the first quarter of 1917, and some considerable sales were made for that delivery. Sales were also made for October-December, 1916. The business for delivery in the first quarter of 1917 was booked at slightly less price than for the current quarter of this year, but differences are now relatively small.

Zinc Sheets continue at the same price. The quotation is $15 per 100, less 8%, f.o.b. Peru, Ill.

Exports from Baltimore during the week included 168,094 lb. of spelter.

Other Metals

NEW YORK—Oct. 4

Aluminum—Demand is strong and in general is in about the same condition as last week, nominal quotations being 61@63c.

Antimony—Market very dull, with many sellers and but few buyers. Sales reported at 11c. We quote the market unchanged at 10½@11½c.

Quicksilver—Market strong on good demand. We quote $77 and sales at that price. San Francisco reports, by telegraph, $74, market firm. The superiority of the New York price is explained by shortage of local stocks and transportation difficulties.

Gold, Silver and Platinum

NEW YORK—Oct. 4

Gold Holdings by the Bank of England against notes has decreased by £611,060, according to report of Samuel Montagu & Co. The Transvaal output for August, 1916, amounted to £3,318,116, as compared with £3,307,975 in August, 1915, and £3,232,891 in July, 1916. During the week of September ending Sept. 9, over £3,600,000 of gold had been received by the United States from Canada.

Platinum—Early in the week sales were made at $85; since then the market became strong again and at the close is quoted at $87½@90.

Our Petrograd correspondent reports that for the period between July 16 and 29 the market was quiet, due to the lessening of the demand by domestic consumers and jobbers. An increase in prices was not expected at once since production was in full swing. Dredging especially was proceeding to full extent. The demand was fully covered by the offering. Prices remained generally unchanged.

In the period between July 30 and Aug. 12 the market improved considerably and toward the end of the period there was some fairly large sales to domestic consumers. The demand was strong and prices improved considerably. The price in Petrograd was $77.42 per oz. and at Ekaterinburg, $71.44 per oz.

Silver—The market has received a slight setback, having declined in the last few days ⅜c. Advices are to the effect that very large quantities of silver have gone from Shanghai to India during the last few months, but sales on that account in quantity are not likely to be continued.

The Silver Undertone continues good in London, according to Samuel Montagu & Co., Sept. 14, although the course of prices has been somewhat uncertain. The recent activity of the Indian Bazaars has simmered down, probably owing to a reduction of their interests in this market. The bear position seems to be practically eliminated, while bulls have realized a portion of their profits. Meanwhile prices in India show some recovery.

The China exchanges have moved up substantially, suggesting the probability of less pressure to sell from that quarter. It will be noticed from details below that silver is being shipped on a considerable scale from San Francisco to China. This partly accounts for the comparatively small offerings of American silver in this market.

Transactions during the week have not been upon a large scale. Buyers have been holding back, and sellers loth to meet them.

The following figures show a fall of 33 lacs in the holding of silver rupees by the Indian treasuries. The last three Indian currency returns received by cable give details in lacs of rupees as follows:

	Aug. 22	Aug. 31	Sept. 7
Notes in circulation...	7,434	7,401	7,356
Reserve in silver coin and bullion.....	2,748	2,737	2,704
Gold coin and bullion..	1,188	1,166	1,154
Gold in England.....	1,192	1,192	1,192

Zinc and Lead Ore Markets

Joplin, Mo., Sept. 9—Price quotations per 2,000 lb.: Blende, high, $66.40 per ton of 60% zinc; premium ore, $65; medium grades, $65@60; low, $55. Calamine, per ton of 40% zinc, $45@35. The average selling price of all grades of zinc ore was $54.07 per ton.

The lead base price was $75@76 per ton of 80% metal content. High price was $76.50, and the average selling price of all grades of lead ore was $74.40 per ton.

Shipments for the week included 7,931 tons of blende, 789 tons of calamine and 1,058 tons of lead ore. The value of all ore shipped for the week was $550,250 and for the year, to date, was $28,203,070.

Another week of large shipping and heavy buying for advance shipment further improved the situation by lowering the stock on hand and disposing of a menacing surplus of ore. With this wiped out, metal prices will have a stronger support in advancing, thus lessening the possibility of a fluctuating ore and metal market, according to the belief of producers.

SILVER AND STERLING EXCHANGE

	Sterling Exchange	Silver New York, Cents	Silver London, Pence		Sterling, Exchange	Silver New York, Cents	Silver London, Pence
Sept.				Oct.			
28	4.7575	69¼	32⅞	2	4.7569	69¼	32⅞
29	4.7569	69¼	32 15/16	3	4.7569	68⅞	32⅞
30	4.7569	69¼	32⅞	4	4.7569	68⅞	32 15/16

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

DAILY PRICES OF METALS IN NEW YORK

	Copper	Tin	Lead		Zinc
Sept. Oct.	Electrolytic	Spot.	N. Y.	St. L.	St. L.
28	26½ @27	39¼	7.00	6.82½ @6.92½	8.87½ @9.12½
29	26½ @27	39¼	7.00	6.82½ @6.92½	8.87½ @9.25
30	26½ @27	39¼	7.00	6.82½ @6.92½	9.00 @9.37½
2	26½ @27	39¼	7.00	6.82½ @6.92½	9.12½ @9.37½
3	26½ @27	39¼	7.00	6.82½ @6.92½	9.12½ @9.37½
4	26½ @27	39¼	7.00	6.82½ @6.92½	9.25 @9.50

The quotations herein are our appraisal of the average markets for copper, lead, spelter and tin based on wholesale contracts for the ordinary deliveries of the trade as made by producers and agencies; and represent, to the best of our judgment, the prevailing values of the metals, reduced to basis of New York, cash, except where St. Louis is basing point.

The quotations for electrolytic copper are for cakes, ingots and wirebars. Electrolytic copper is commonly sold at prices including delivery to the consumers and is subject to discounts, etc. The price quoted for copper on "regular terms" (r.t.) is the gross price including freight to the buyer's works and is subject to a discount for cash. The difference between the price delivered and the New York cash equivalent is at present about 0.25c. on domestic business. The price of electrolytic cathodes is 0.05 to 0.10c. below that of electrolytic. Quotations for lead represent wholesale transactions in the open market for good ordinary brands. Quotations for spelter are for ordinary Prime Western brands. Only St. Louis price is given, St. Louis being basing market. We quote New York price at 17c. per 100 lb. above St. Louis.

Some current freight rates on metals per 100 lb. are: St. Louis-New York 17c.; St. Louis-Chicago, 6.3c.; St. Louis-Pittsburgh, 13.1 cents.

LONDON

	Copper			Tin		Lead	Zinc
	Standard		Electrolytic				
Sept. Oct.	Spot	3 Mos.		Spot	3 Mos.	Spot	Spot
28	117½	114	139	174½	174¾	31½	52
29	118½	115	140	175½	175½	32	52
30	...	...	...	...	...	...	...
2	119	115½	140	175¼	175¼	31½	52
3	119½	116	140	175¾	175¾	31½	52
4	120	116¼	141	176¾	177	31½	54

The above table gives the closing quotations on London Metal Exchange. All prices are in pounds sterling per ton of 2,240 lb. Copper quotations for electrolytic are subject to 3% discount. For convenience in comparison of London prices, in pounds sterling per 2,240 lb., with American prices in cents per pound the following approximate ratios are given, reckoning exchange at 4.80. £15 = 3.21c.; £20 = 4.29c.; £30 = 6.43c.; £40 = 8.57c.; £60 = 12.85c. Variations, £1 = 0.21⅜ cents.

The excessive summer drought, yet unbroken, is partly responsible for a number of mines being still out of commission, while preparations are making for drilling 1,200 to 1,500 ft. for water for wet concentration.

Until noon yesterday the zinc-ore market was a weak factor, but after that no ore sold under $63@65 base. Lead continues advancing.

Platteville, Wis., Oct. 1—Quotations of the district are according to the following figures: Base price, per 2,000-lb. ton for material assaying 60% zinc, is $58 for premium ore, down to $50 for medium grade. For material assaying 80% lead, the base price per 2,000-lb. ton is $74. Shipments for the week were 3,178 tons of zinc ore, 42 tons of lead ore, and 929 tons of sulphur ore. For the year to date the figures are 93,936 tons of zinc ore, 3,275 tons of lead ore, and 23,002 tons of sulphur ore. Shipped during the week to separating plants, 3,099 tons of zinc ore. The shipment to date of zinc ore to smelteries shows an increase of 22,180 tons over the corresponding period of last year.

The Peruvian government, through the Ministry of Finance, has authorized the Banco Mercantil Americano to have coined 50,000 Peruvian pounds ($243,325) in gold disks imported by the bank. The "West Coast Leader" of Aug. 24 states that this bank will import a first consignment of gold amounting to $500,000. The gold disks are to be exempt from import duty, and they are to be coined free of charge. The Banco Mercantil is to turn over half of the coined gold to the government in exchange for Peruvian bank notes of the same value.

Other Ores

Tungsten Ore—Business was done in several quarters at $16@17, and we quote the market at that figure, unchanged from the previous week.

Charles Hardy in his latest weekly report (Oct. 3) gives the following interesting information: "Several hundred tons have changed hands and though the prices have not improved beyond $17, very considerable business has been done at that figure for home consumption and for export. An additional factor of interest is the placing here of considerable orders for ferro-tungsten and tungsten powder which amounted to close upon 200 tons during the past week, and this is equivalent to a maximum of 300 tons of tungsten ores. Though I hear of quotations below $17, I have found no difficulty in obtaining this figure wherever the buyer was actually ready to place his business. The foreign market continues to show an active demand for our ores and further business can be looked forward to with certainty. Ferro-tungsten has been sold at $2.60 per lb. tungsten contained."

Antimony Ore—Ore of 50% grade, for immediate delivery, was sold at $1.10 per unit.

Molybdenum Ore—Charles Hardy reports that molybdenum ore seems to be becoming more and more of a favorite with the ferroalloy manufacturers, and whereas the sales in this country were made previously to only one or two quarters, there are now a number of manufacturers actively inquiring for and buying molybdenite. This demand has influenced prices to such an extent that the latest sales were made at prices ranging from $1.50@1.75 per lb. MoS_2 contained in the ore.

Iron Trade Review

NEW YORK—Oct. 3

The iron and steel markets continue strong. A car shortage cut down shipments in the Pittsburgh district, and there has been some labor shortage.

Domestic buying of finished steel for delivery after Jan. 1 is not heavy. Following various sellers' refusals to consider forward contracts a good many consumers are now disposed to take the market as they find it. Now and then surprisingly early deliveries seem to be available, but such cases are only eddies in a generally strong current.

There are signs of fresh export buying for every-day rather than war purposes. It is now several months since the last considerable demand of this sort. Italy is a large general buyer, all apart from the Italian inquiry for 45,000 tons of billets for shells, on which delivery is asked as soon as it can be made. Wire, plates, sheets and tinplates are wanted in large quantities for various foreign markets.

There is a heavy demand for bessemer and basic iron with large sales, according to "Iron Age," and a good movement in foundry iron. One fairly large block of basic iron for last quarter and first quarter shipment has been sold at $19 or better, Valley furnace, and there has also been a fairly large sale of bessemer iron at $22 or better. A Cleveland furnace interest has sold 16,000 tons of basic to the American Steel Foundries at Sharon, Penn., and another interest has sold 12,000 tons of basic, 2,000 tons per month for the first half of 1917, at the average monthly market price. We also note a sale of 2,000 tons of bessemer for fairly prompt shipment at $22.50, Valley furnace. The Trumbull Steel Co., which is to build an openhearth steel plant at Warren, Ohio, has an inquiry out for 6,000 tons of basic iron per month for the first half of next year. While its steel plant will not be ready for operation before the latter part of next year, it is said that if the company buys this iron it will pile it, and the object in trying to get iron now is to have it ready for the steel plant when it is finished. We note a sale of 15,000 tons of basic to a Youngstown interest at $19, Valley furnace, to be delivered as soon as the seller can ship it. Quotations have been advanced and are now as follows: Basic, $19@19.25; standard bessemer, $22@22.50; No. 2 foundry, $18.50@19; malleable bessemer, $19@19.25; and gray forge, $18.25@18.50, all at Valley furnace, the freight to Pittsburgh and Cleveland districts being 95c. per ton.

BIRMINGHAM, ALA.—Sept. 26

Business in foundry iron has been very active for the past four weeks, and there have been also some sales of basic pig. The tonnage sold since the present movement began late in August has been a little over 200,000 tons. Most of this is for fourth-quarter delivery but quite a number of contracts run into 1917. Prices have been on a basis of $14.50@15 per ton for No. 2 foundry, Birmingham. There is not much to be had at $14.50 now, and $15 seems to be the assured price for the rest of the year.

The steel works at Ensley are very busy and are turning out ingots as fast as possible. Coke is in strong demand and prices are firm.

PITTSBURGH—Oct. 3

Conditions in the steel market have been relatively quiet in the past week, but a fair volume of business has been done. The mills are quite reserved in the matter of selling and are confining their operations chiefly to the making of sales of definite tonnages for specific uses. It is stated that they could book a much larger tonnage if they were willing to accept ordinary open contracts.

Steel prices show a further hardening tendency. Following the Carnegie Steel Co.'s advance last Tuesday of $2 a ton on shapes, to 2.70c., some of the independents are quoting the advanced price on some of their inquiries, and on corresponding business are quoting 2.70c. on bars also, the Carnegie bar price remaining at 2.60c. The regular 3.00c. price on plates is becoming nominal, higher prices being usually quoted even for the second half of 1917. The Steel Corporation is stated to have actual specifications against its plate production for 13 months. The American Sheet and Tin Plate Co. has advanced its prices $2 a ton on blue annealed to 3c. basis, and $3 a ton on black and galvanized, to 3.15c. and 4.40c. respectively, all for bessemer, openhearth sheets being 10c. per 100 lb. higher. Independents are gradually withdrawing lower prices. It is expected that books will be opened shortly, at the advanced prices, for first-quarter or first-half contracts. The advance in wire products predicted in some quarters has not occurred as yet.

The Sinclair Oil Co. has let about two-thirds of the 60,000 tons of line pipe required for 800 mi. of oil line, two independents joining in the sales, at slightly below the market for small lots, but at a high price for such a large tonnage.

Pig Iron—Pig iron has continued to stiffen, with fairly heavy buying and with reduced offerings. It appears that the furnace have little unsold tonnage to the middle of next year, bessemer being especially scarce. Among buyers of basic have been Republic, Newport and Middletown. Basic is 50c. higher, at least 15,000 tons having been sold at $19.50, Valley, for delivery October to January, inclusive. The French government is figuring on 25,000 tons of basic, foreign inquiry having hitherto been almost wholly of bessemer. Offerings of bessemer at the reputed market and even at higher prices are very limited. Foundry is stiffening with fair demand and prospects of reduced make on account of the call for basic. The market is strong as follows: Bessemer, $22.50; basic, $19.50; malleable and foundry, $19@19.50; forge, $18.50@19, f.o.b. Valley furnaces, 95c. higher delivered Pittsburgh. W. P. Snyder & Co. report average prices realized on all market sales of Valley iron in 1,000-ton lots and over in September at $21.9346 for bessemer, an increase of 93c., and at $18.63 for basic, an increase of 63c. The average quoted price of foundry iron in September was $18.58, Valley.

Steel—The scarcity of unfinished steel promises to grow still more acute. While $45@50 is regarded as nominally the market for billets and sheet bars there are practically no offerings and it is probable that more than $50 would be bid for billets. It is certain that more would be bid for slabs. The Edgewater Steel Co., which expects to complete two open-hearth furnaces by the end of this year, has already sold the prospective output of ingots, until its rolling-mill capacity becomes available at an indefinite date later. Rods are nominal at $55@60 for soft, prices running up to $90 for high carbon.

Ferroalloys

Ferromanganese—The market has been firming up after the recent rather sharp competition between domestic and foreign producers and $165 is now quoted on contract for either, the claim being made that no shading is now possible. Prompt is quoted at $165. Buyers seem to be well covered and are not active in the market.

Ferrosilicon is slightly easier. High-grade, 50%, is quoted at $86 in carload lots and down to $84 in 600-ton lots. A sharp demand for bessemer ferrosilicon continues and prices have been advanced $1 per ton by Ohio makers to a basis of $31, furnace, for 10%. It is estimated that recent sales of this metal have totaled at least 5,000 tons, some of which has been for export, and there is unclosed inquiry for 5,000 to 6,000 tons now in the market. One or two good-sized lots for foreign buyers are included in the latter.

Spiegeleisen has been more in demand for export, sales running up to 1,000 tons. The market is represented by about $40, at furnace, for 20% material.

Foreign Iron

British Exports of Iron and Steel—Advance information to "Iron Age" regarding British exports of iron and steel and manufactures thereof is that the total for August, 1916, was £5,986,292, which exceeds the value for August, 1915, by £2,452,568 and that for August, 1914, by £3,690,941. Imports of iron ore, scrap iron and steel increased noticeably, the total value being £1,266,585, or an increase of £597,240 over August, 1915.

Japanese Iron Production—The Japan "Times" states that since the restriction of iron and steel exports from the west, more strenuous efforts have been put forth to obtain iron ores in Japan. These have been successful and the total output for May showed an increase of 67% over last year and that for the five months of the year an increase of 42%. The expectation is that in a few years the country's iron and steel output will be increased 300 to 500%.

German Steel Production in July, according to the statement of the German Iron and Steel Union, was 1,366,107 metric tons, an increase of 46,789 tons over June. For the seven months ended July 31 the total was: Converter, 4,486,234; openhearth, 3,873,124; direct castings, 592,887; crucible, 62,540; electric, 100,249; total, 9,126,234 tons. This is 1,842,285 tons more than for the eight months in 1915, but 1,889,442 tons less than in 1914.

Coke

Inquiries are in the market for blast-furnace coke for the first half of next year and one contract for about 10,000 tons per month of high-grade coke has been closed for that delivery at $3 per net ton at oven. It is expected that other contracts will be closed early in October. Indications favor higher prices for furnace coke for the first half of next year than ruled in the second half of this year. The demand for prompt furnace coke is active, and high grades readily bring $3 and in some cases $3.10 and in a few instances $3.25 per net ton at oven.

Connellsville—Spot furnace coke is up 25c., there having been sales for several days at $3.50, with $3.65 reported as being occasionally obtained. Production is restricted by labor scarcity, while the high prices obtainable for coal make coke quotations higher for both spot and forward. There is still larger inquiry in the market, and two contracts, for 7,000 or 8,000 tons a month each, have been put through at $3.25, one for the first quarter and the other for the first half of next year. This is now the usual quoting price, but it is understood there are some options still out at $3 or less. We quote: Spot furnace, $3.50; contract, $3.25; spot and contract foundry, $3.50@3.75, per net ton at ovens.

Chemicals

NEW YORK—Oct. 4

The general market continues strong with heavy chemicals in good demand at steady prices.

Arsenic—Absence of new buyers has resulted in an easier market. Immediate delivery easily secured of car lots at 5¾c. per lb. with smaller quantities held at 6c. per lb. Red arsenic, however, is reported very scarce and firmly held at about 65c. per lb. for spot.

Copper Sulphate—Market still steady with grade, quantity and brand the determining factors in fixing prices. Spot offerings of small crystals have been made at 8½c. per lb. with prime large crystals quoted at 10@10¼c. per lb., according to quantity.

Nitrate of Soda—Valparaiso advices indicate undoubtedly stronger market with prices on the upgrade. Domestic markets easy with prices still favoring the buyers. Quotations range from $2.90@2.95 per 100 lb. for both spot and future.

Potash—Earlier reports of extensive deposits of potash salts discovered in Cuba are still lacking confirmation. Muriate of potash very firm and quoted at from $400@420 per ton.

Sulphuric Acid—Prices continued steady, although it is reported that some contracts for 66° acid in tanks have been offered at $22 per ton and might be further shaded on a long-time contract. Spot prices reported for 66° at 1½c. per lb. with 1c. per lb. asked for 60° acid sold for prompt shipment.

Nitric Acid—Carboys of 42° acid quoted at 7c. per lb. for spot. Aqua fortis quoted at ¼c. per lb. less than pure nitric acid. On long-time contracts sellers are reported to shade prices ½c. per lb.

Assessments

Company	Delinq.	Sale	Amt.
Alpha, Nev.	Oct. 25	Nov. 15	$0.03
Andes, Nev.	Oct. 11	Nov. 1	0.02
Beaver Mines, Utah	Sept. 30	Oct. 21	0.0025
Blue Bell, Ida.	Oct. 9	Nov. 9	0.002
Blue Bull, Nev.	Oct. 16	Nov. 20	0.01
Blue Star, Ida.	Sept. 25	Oct. 21	0.02
Boston Dev., Utah	Sept. 27	Oct. 14	0.03
Buffalo Cons., Utah	Sept. 23	Oct. 14	0.005
Bull Valley, Utah	Oct. 10	Oct. 31	0.004
Cash Boy, Nev.	Sept. 1	Oct. 15	0.01
Chief Cons. Ext., Utah	Oct. 10	Nov. 1	0.002
Consolidated Imperial, Nev.	Oct. 25	Nov. 15	0.01
Con. Virginia, Nev.	Sept. 29	Oct. 20	0.05
Diam. Blk., Butte, Nev.	Oct. 12	Nov. 18	0.01
Eagle Mountain, Ida.	Oct. 2	Nov. 4	0.001
Four Timbers, Ida.	Oct. 1	Nov. 1	0.002
Giant, Ida.	Oct. 5	Nov. 9	0.003
Gold Bond, Utah	Sept. 29	Oct. 24	0.001
Goldstrike Bon., Utah	Sept. 25	Oct. 16	0.0025
Great Western, Nev.	Sept. 26	Oct. 18	0.01
Idaho-Nevada, Ida.	Sept. 14	Oct. 14	0.002
Independent, Ida.	Oct. 7	Nov. 7	0.005
Leonora, Utah	Sept. 27	Oct. 16	0.005
Manhattan Cons., Nev.	Oct. 9	Nov. 8	0.01
Military, Ida.	Oct. 25	Nov. 25	0.000½
Monarch-Pgh., Nev.	Oct. 23	Nov. 27	0.01
Murray Copper, Utah	Oct. 9	Nov. 8	0.001
New Balbic, Mich.	Oct. 14	.....	1.00
North Tintic, Utah	Oct. 10	Nov. 1	0.002
Ophir, Nev.	Oct. 25	Nov. 15	0.05
Rio Grande Grubstake, Nev.	Sept. 22	Oct. 31	0.002
Royal Copper, Ida.	Sept. 22	Oct. 22	0.001
Seg. Belcher, Nev.	Oct. 30	Nov. 24	0.02
Sierra Nevada, Nev.	Oct. 12	Nov. 2	0.10
Silver Pick, Nev.	Sept. 25	Oct. 30	0.01
Smuggler, Utah	Sept. 20	Oct. 18	0.005
Spearhead, Nev.	Oct. 2	Nov. 2	0.01
Tarbox, Mont.	Sept. 28	Oct. 28	0.005
Tonopah-Bonanza, Nev.	Sept. 19	Oct. 16	0.01
Umatilla, Nev.	Sept. 18	Oct. 24	0.0025
Uvada, Nev.	Oct. 9	Oct. 26	0.02
Diamondfield Bl'k B'tte, Nev.	Oct. 12	Nov. 18	0.01

Stock Quotations

SAN FRANCISCO Oct. 3	
Name of Comp.	Bid.
Alta	.05
Andes	.08
Best & Belcher	.05
Bullion	.01
Caledonia	.30
Challenge Con.	‡.08
Confidence	.20
Cons. Imperial	.01
Con. Virginia	.14
Gould & Curry	.03
Hale & Norcross	.08
Jacket-Cr. Pt.	.05
Mexican	.16
Occidental	.70
Ophir	.19
Overman	.06
Savage	.11
Seg Belcher	.02
Sierra Nevada	.22
Union Con.	.61
Utah Con.	.02
Belmont	4.60
Jim Butler	.90
MacNamara	.05
Midway	.23
Mont.-Tonopah	.21
North Star	.16
Rescue Eula	.24
West End Con.	.77
Atlanta	.09
Blue Bell	‡.01
Booth	.12
C.O.D. Con	.03
Comb. Frac	.06
D'field B.B.	.03
D'field Daisy	.06
Jumbo Extension	.36
Round Mountain	.39
Sandstorm Kendall	.03
Silver Pick	.21
Central Eureka	.04
Argo	.10
Ariz. Central	.15
Big Jim	1.37½
Lazy Boy	.10
Oatman No. Star	.14
Tom Reed	2.00
United Eastern	3.62½
United Western	.06
LONDON	Sept. 21
Alaska-Mexican	£0 17s 6d
Alaska Tre'dwell	4 5 0
Burma Corp.	4 2 6
Cam & Motor	0 11 0
Camp Bird	0 7 6
El Oro	0 9 6
Esperanza	0 11 6
Mexico Mines	3 17 6
Nechi, pfd.	0 12 9
Oroville	0 16 6
Santa Gert'dis.	0 12 0
Tomboy	1 1 6

SALT LAKE Oct. 3	
Name of Comp.	Bid.
Big Four	1.00
Black Jack	.09
Cardiff	7.50
Colorado Mining	.19
Crown Point	.06
Daly-Judge	7.80
Emma Cop.	3.50
Gold Chain	.23
Grand Central	.74
Iron Blossom	1.57½
Lower Mammoth	.05
May Day	.13
Opohongo	.01½
Prince Con.	1.35
Seven Troughs	.03
Silver King Coal'n	2.97½
Silver King Con.	3.70
Sioux Con.	.16
So. Hecla	2.05
Uncle Sam	.04
Wilbert	.06½
Yankee	.16
COLO. SPRINGS Oct. 3	
Acacia	.03½
Cresson	6.12
Doctor Jack Pot	.09½
Elkton Con.	.15
El Paso	.44
Findlay	.03½
Gold Sovereign	.06
Golden Cycle	2.33
Granite	.73
Isabella	.21
Jack Pot	.05
Jerry Johnson	‡.04
Mary McKinney	.31
Portland	1.90
Vindicator	1.96
TORONTO Oct. 3	
Adanac	‡.25
Bailey	.07½
Chambers Ferland	.19
Coniagas	4.55
La Rose	.58
Peterson Lake	.23
Right of Way	.05
Seneca Superior	.29
T. & Hudson Bay	70.00
Temiskaming	.64
Wettlaufer-Lor.	.11
Dome Exten.	.35
Dome Lake	.56
Foley O'Brien	.62½
Hollinger	6.75
Jupiter	.27
McIntyre	1.46
Newray	.70
Porcu. Crown	.66
Vipond	.36
West Dome	.36

N. Y. EXCH. Oct. 3	
Name of Comp.	Clg.
Alaska Gold M.	12½
Alaska Juneau	7
Am.Sm.&Ref.,com	113½
Am. Sm. & Ref., pf.	116½
Am. Sm. Sec., pf. A	96
Am. Sm. Sec., pf. B.	88
Am. Zinc	41⅞
Am. Zinc, pf.	75
Anaconda	96⅜
Batopilas Min.	1⅞
Bethlehem Steel	550
Bethlehem Steel, pf.	137
Butte & Superior	64½
Chile Cop.	21½
Chino	56½
Colo. Fuel & Iron	60½
Crucible Steel	95
Dome Mines	25
Federal M. & S.	16
Federal M. & S., pf.	41
Great Nor., ore ctf.	45⅜
Greene Cananea	51
Homestake	130
Inspiration Con.	66⅞
International Nickel	54⅜
Kennecott	55⅝
Lackawanna Steel	87⅜
Miami Copper	38⅛
Nat'l Lead, com.	69⅞
National Lead, pf.	116½
Nev. Consol.	22⅛
Ontario Min	‡7
Quicksilver	2⅜
Quicksilver, pf.	4
Ray Con.	25⅛
Republic I&S, com.	81⅜
Republic I&S, pf.	112⅛
Sloss-Sheffield	64½
Tennessee Copper	24⅜
Utah Copper	95½
U. S. Steel, com.	117⅛
U. S. Steel, pf.	121⅛
Va. Iron C. & C.	47½

N. Y. CURB Oct. 3	
Beaver Con.	.42
Buffalo Mines	1.00
Butte & N. Y.	1⅛
Butte C. & Z.	6⅞
Caledonia	.59
Can. Cop. Corpn.	1⅛
Cashboy	.07
Cerro de Pasco	39½
Con. Ariz. Sm.	1½
Con. Coppermines	2½
Con. Nev.-Utah	.28½
Crystal Cop.	1½
First Nat. Cop.	.5
Florence	.72
Goldfield Con.	.60
Goldfield Merger	.07
Granite	.39
Hecla Min.	5½
Howe Sound	5
Jerome Verde	2½
Joplin Ore & Spel.	‡.52
Kerr Lake	4⅜
Magma	18⅜
Majestic	.62
McKinley-Dar-Sa.	.62
Mother Lode	.34½
Nevada Hills	.20
N. Y. & Hond.	15½
Nipissing Mines	8½
Oro	.03
Ray Hercules	3⅜
Rochester Mines	.54
St. Joseph Lead	18
Standard S. L.	1⅛
Stewart	.25
Success	.36
Tonopah	5½
Tonopah Ex.	5½
Tribullion	⅜
United Verde Ext.	40½
United Zinc	4½
White Knob, pf.	1⅞
White Oaks	4⅜

BOSTON EXCH Oct. 3	
Name of Comp.	Bid
Adventure	4½
Ahmeek	105
Algomah	1½
Alloues	69½
Ariz. Com., ctfs.	13½
Bonanza	.40
Butte-Balaklava	2
Calumet & Ariz.	76
Calumet & Hecla	585
Centennial	23
Copper Range	70
Daly West	2⅜
East Butte	16½
Franklin	8½
Granby	92⅜
Hancock	14
Helvetia	.35
Indiana	3½
Island Cr'k, com.	44
Island Cr'k, pfd.	90½
Isle Royale	33
Keweenaw	6⅜
Lake	14½
La Salle	5
Mason Valley	4½
Mass	15½
Mayflower	2⅜
Michigan	4
Mohawk	93
New Arcadian	7
New Idria	13
North Butte	22½
North Lake	2½
Ojibway	1⅜
Old Colony	2½
Old Dominion	71
Osceola	89¼
Quincy	90
St. Mary's M. L.	88
Santa Fe	2⅛
Shannon	9½
Shattuck-Ariz.	30⅜
So. Lake	6⅜
So. Utah	.35
Superior	17
Superior & Bost.	4⅜
Tamarack	40⅜
Trinity	7⅛
Tuolumne	.57
U. S. Smelting	75⅜
U. S. Smelt'g, pf.	52
Utah Apex	4⅛
Utah Con.	15
Utah Metal	8⅜
Victoria	4⅜
Winona	5⅛
Wolverine	48
Wyandot	1⅜
BOSTON CURB Oct. 3	
Bingham Mines	11½
Boston Ely	.97
Boston & Mont.	.99
Butte & Lon'n Dev.	.75
Calaveras	5⅛
Calumet-Corbin	.02½
Chief Con.	2
Cortez	.35
Crown Reserve	.55
Davis-Daly	2⅛
Eagle & Blue Bell	1⅛⅝
Houghton Copper	1½
Iron Cap Cop., pf.	5½
Mexican Metals	.33
Mines of America	2½
Mojave Tungsten	4⅜
Nat. Zinc & Lead	.80
Nevada-Douglas	1⅜
New Baltic	1½
New Cornelia	17⅛
Ohio Copper	.12
Oneco	.80
Raven Copper	‡.07
Rex Cons.	.29
Rilia	.14
Yukon Gold	2½

‡Last Quotations.

Monthly Average Prices of Metals

SILVER

Month	New York			London		
	1914	1915	1916	1914	1915	1916
January	56.572	48.855	56.775	26.553	22.731	26.960
February	57.506	48.477	56.755	26.573	22.753	26.975
March	58.067	50.241	57.935	26.788	23.708	27.597
April	58.519	50.250	64.415	26.958	23.709	30.662
May	58.175	49.915	74.269	26.704	23.570	35.477
June	56.471	49.034	65.024	25.948	23.267	31.060
July	54.678	47.519	62.940	25.219	22.597	30.000
August	54.344	47.163	66.083	25.979	22.780	31.498
September	53.290	48.680	68.515	24.260	23.591	32.584
October	50.654	49.385	.....	23.199	23.925	.....
November	49.082	51.714	.....	22.703	25.094	.....
December	49.375	54.971	.....	22.900	26.373	.....
Year	54.811	49.684	.....	25.314	23.675	.....

New York quotations cents per ounce troy, fine silver; London, pence per ounce, sterling silver, 0.925 fine.

COPPER

Month	New York Electrolytic		London Standard		London Electrolytic	
	1915	1916	1915	1916	1915	1916
Jan.	13.641	24.008	60.756	88.083	65.719	116.167
Feb.	14.394	26.440	63.494	102.667	*	133.167
Mar.	14.787	26.310	66.152	107.714	*	136.000
April	16.811	27.895	75.096	124.319	*	137.389
May	18.506	28.625	77.600	135.457	*	152.522
June	19.477	26.601	82.574	112.432	95.333	137.455
July	18.796	23.865	76.011	95.119	91.409	125.500
Aug.	16.941	26.120	68.673	110.283	82.333	126.304
Sept.	17.502	26.855	68.915	113.905	85.250	134.071
Oct.	17.686	.....	72.601	.....	88.000	.....
Nov.	18.627	.....	77.744	.....	93.273	.....
Dec.	20.133	.....	80.773	.....	100.43	.....
Year	17.275	.....	72.532	.....	.....	.....

TIN

Month	New York		London	
	1915	1916	1915	1916
January	34.260	41.825	156.550	175.548
February	37.415	42.717	176.925	181.107
March	48.426	50.741	180.141	193.609
April	47.884	51.230	166.225	199.736
May	38.790	49.125	162.675	196.511
June	40.288	42.231	167.636	179.466
July	37.423	38.510	167.080	168.357
August	34.389	38.565	151.440	169.870
September	33.125	38.830	152.625	171.345
October	33.080	.....	151.554	.....
November	39.224	.....	167.670	.....
December	38.779	.....	167.000	.....
Av. year	38.590	.....	163.960	.....

LEAD

Month	New York		St. Louis		London	
	1915	1916	1915	1916	1915	1916
January	3.729	5.921	3.548	5.826	18.606	31.167
February	3.827	6.246	3.718	6.164	19.122	31.988
March	4.053	7.136	3.997	7.375	21.883	34.440
April	4.221	7.630	4.142	7.655	21.094	34.368
May	4.274	7.463	4.182	7.332	20.347	32.967
June	5.932	6.936	5.836	6.749	25.170	31.011
July	5.659	6.352	5.531	6.185	24.611	28.137
August	4.656	6.244	4.520	6.088	21.946	29.734
September	4.610	6.810	4.490	6.699	23.151	30.786
October	4.600	.....	4.499	.....	23.994	.....
November	5.155	.....	5.078	.....	26.278	.....
December	5.355	.....	5.266	.....	28.807	.....
Year	4.673	.....	4.567	.....	22.917	.....

SPELTER

Month	New York		St. Louis		London	
	1915	1916	1915	1916	1915	1916
Jan.	6.386	16.915	6.211	16.745	30.844	89.810
Feb.	8.436	18.420	8.255	18.260	39.819	97.762
Mar.	8.541	16.846	8.360	16.676	44.141	95.048
April	10.012	16.695	9.837	16.525	49.888	99.056
May	14.781	14.276	14.610	14.106	68.100	94.217
June	21.208	11.752	21.038	11.582	100.614	68.591
July	19.026	8.925	18.856	8.755	97.250	50.750
Aug.	12.781	8.730	12.611	8.560	67.786	51.587
Sept.	13.440	8.990	13.270	8.820	67.841	52.095
Oct.	12.800	.....	12.596	.....	66.536	.....
Nov.	15.962	.....	15.792	.....	88.409	.....
Dec.	15.391	.....	15.221	.....	89.400	.....
Year	13.230	.....	13.054	.....	67.553	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton. * Not reported.

PIG IRON IN PITTSBURGH

Month	Bessemer‡		Basic‡		No. 2 Foundry	
	1915	1916	1915	1916	1915	1916
January	$14.59	$21.60	$13.45	$18.78	$13.90	$19.70
February	14.55	21.16	13.45	18.93	13.90	19.51
March	14.55	21.81	13.45	19.20	13.95	19.45
April	14.55	21.65	13.45	18.95	13.95	19.45
May	14.61	21.78	13.60	19.11	13.83	19.58
June	14.70	21.95	13.67	18.95	13.77	19.34
July	14.94	21.95	13.91	18.95	13.68	19.20
August	16.01	21.95	15.31	18.95	14.75	19.25
September	16.86	.....	15.95	.....	15.70	.....
October	16.95	.....	15.96	.....	15.80	.....
November	17 57	.....	16.47	.....	17.20	.....
December	19.97	.....	18.44	.....	18.95	.....
Year	$15.82	.....	$14.76	.....	$14.95	.....

‡As reported by W. P. Snyder & Co.

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